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ATKINSON's
EPITOME
Of the Art of
NAVIGATION.

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EPITOME
OF THE
Art *of* Navigation;
OR, A
Short and Eaſy Methodical Way to become a *Compleat Navigator.*

CONTAINING

Practical Geometry, Plain and Spherical, Superficial and Solid; with its Uses in all Kinds of Menſuration.

Trigonometry, Plain and Spherical, both Geometrical, Inſtrumental, Logarithmetical; with its Uses in NAVIGATION, *viz.*

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The Deſcription and Uſe of the *Plain*-Chart, *Mercator*'s-Chart, both Globes, Hemiſpheres, and divers other Inſtruments.
A New Form of keeping a Sea-Reckoning, or Account of a Ship's Way.

A Traverſe-Table; a Table of Meridional Parts; a Table of 10,000 Logarithms, and Logarithmetical Sines, Tangents and Secants, carefully Corrected.

By *JAMES ATKINSON, Senior.*
TEACHER of the MATHEMATICKS.

LONDON:
Printed for *Thomas Page*, and *William Mount*, on *Tower-Hill* and *James Atkinſon*, near *Cherry-Garden-Stairs*, on *Rotherhith-Wall*, M,DCC,XXXII.

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*

To all Lovers and Learners

OF

NAVIGATION.

THE *General Approbation* of this *Book*, *ſince its firſt Impreſſion in* 1686, hath obliged me not only to publiſh my *Grateful Acknowledgment* thereof; but alſo excited my diligent Search into, and exact Survey of every Part of it's *Structure*, to find out the *Defects*, to know all it's *Deficiencies*, which I have ſo far laboured in: That in this Ninth Impreſſion,

I have now *Rectified* what was Amiſs; *Alter'd* what was Diſorderly; *Explain'd* what was Dark or Obſcure; *Enlarged* where it was Skanty, added where it was Wanting. And

Theſe *Ratifications*, *Alterations*, *Emendations*, and *Additions*, being in divers Places, I thought it needleſs to *Enumerate* them; for they are obvious to a diligent *Reader*, that will but compare the *Rules*, *Precepts*, and *Examples* of this with the former *Impreſſions*, in the plain and eaſy Method they are placed in, which is thus;

I. *You have* Practical Geometry, *explained by* Definitions, Problems *and* Proportions. *In this Chapter is taught the making the moſt uſeful* Geometrical Figures, *with the meaſuring all* Superficies *and* Solids; *Alſo the* Application *thereof in Practical Meaſuring*, Board, Glaſs, Plaiſtering, Painting, Paving, *and* Land: Timber *and* Stone; Gauging of Casks, *and a* Ship's Hold: *All being illuſtrated with* Rules, Proportions, *and* Examples, *eaſy to the Underſtanding, and not burthenſome to the Memory*; *and ſo ſtated that they may be performed both by* Arithmetick, *and by the* Line of Numbers *on* Gunter'*s-Scale, in* 37 Problems.

The firſt Chapter I adviſe the Learner to ſtudy well before he proceed, it being preparative to the next, as indeed they are all depending on one another, as Links in a Chain.

II. Plain Trigonometry *is next, in which are many uſeful Notes, and Definitions, with the Axioms, and alſo the Caſes depending on each Axiom, orderly ſet down in* 8 Problems, *containing* 13 Caſes.

And here I muſt advertiſe the Young Student that would work Trigonometry *by the* Logarithms, *to conſult Chapter* 1. The Explanation and General Uſe of the Table of Logarithms, and Tables of Sines, Tangents, and Secants, *towards the latter End of the Book; in* Page 294.

III. *Then follows* Plain Trigonometry, *applied in* Problems *of Sailing by the* Plain Sea-Chart, *commonly called* Plain Sailing.

And that nothing be wanting, I begin with the common Notes of the Julian Kalendar; *ſhewing how to find the* Prime, Epact, Dominical Letter, Eaſter Day, the Moon's Age, Southing, *and Time of* Full-Sea, or High-water. *In* 9 Problems.

Then proceeding to the Deſcription *and* Uſe *of the* Plain Chart, *in* 5 Problems, *before I come to the* Caſes *of* Plain Sailing, *which I divide into* 3 *Parts.*

1. *In a* Right-angle Triangle *relating to a ſingle Courſe; in which are* 6 Caſes, *commonly called the* 6 Caſes of Plain Sailing.

2. *In a* Right angle Triangle *relating to ſeveral Courſes called a* Traverſe.

2. *In an* Oblique Triangle, *in which are but* 4 Caſes, *though there may be a Multitude of various* Queſtions; *of which you have a Taſte in* Turning to Windward, *and* Sailing in Currents. *In* 21 Problems.

IV. *In Chapter* 4. *is* Mercator's Sailing: *To the right underſtanding of which, 'tis neceſſary to deſcribe Mr.* Wright's Projection, *commonly known by the Name of* Mercator's Chart, *and ſhew the Uſes of it, before I treat of the* Problems *of* Sailing *by it; which you will find performed in* 12 Problems. *In the firſt* 9 *the Table of* Meridional Parts, *or the* Meridional Line *on* Gunter's Scale *is uſed. And in Caſe that Table or Line be wanting, to ſupply their room, I have added* Problems of Sailing by the Middle Latitude, *which will nearly agree with* Mercator's Sailing, *a thing of good Uſe. In* 4 Problems.

V. Spherical Trigonometry, *or the Doctrine of* Spherical Triangles Rectangular *and* Oblique, *is next in Order; and its being ſo neceſſary, you ſhould underſtand how to make a Spherical* Triangle, *and alſo how to meaſure any of its Parts, before the framing and working Proportions therein, I have fully explain'd that Matter in the beginning of this* Chapter, *being in a Manner a New Invention, I call* Spherical Geometry: *This you have in* 21 Problems.

And in Spherical Trigonometry *it ſelf, (the next in Order) you have all the* Axioms *and* Caſes, *both in* Rectangular *and* Obliquangular Triangles, *explained with neceſſary Notes on each Caſe: As to know when a required Angle is* Acute or Obtuſe; *and when a required Side is more or leſs than a* Quadrant. *In* 12 Problems, *containing* 28 Caſes.

VI. The Deſcription and Uſe of both Globes, *is the next to be conſider'd; in which I have plainly and familiary explained and ſhewed the Uſe of the moſt neceſſary things belonging or relating to each of them: In* 24 *uſeful* Problems.

To which is annexed a ſhort Deſcription and Uſe of the Hemiſpheres, *projected on the* Plain of the Ecliptick.

VII. Geography *is the Subject of this Chapter, which is the Application of* Spherical Trigonometry *in finding the* True Diſtance of Places *in the Variety of their Situation on the* Globe of the Earth. *In* 4 Problems.

VIII. Great Circle Sailing *comes next, which as it's the exacteſt Way of Sailing, ſo it's the moſt difficult, and hardly poſſible for a Ship exactly to ſail by; yet its of great Advantage to keep conveniently near it: for which Purpoſe you'll find all that neceſſarily belongs or relates to it, both as to the* Projective Part, *and that both* Stereographical *and* Gnomonical; *as alſo in the* Calculative Part, *which is the Application of both* Spherical *and* Plain Trigometry, *fully made out; With an Intimation of ſhortning the Work, by ſhewing how to deſcribe the Arch a* Great Circle *in a* Mercator's-Chart. *In* 4 Problems

IX. *Next you have* Spherical Trigonometry, *applied in ſundry* Aſtronomical Problems *uſeful in Navigation, wherein the Circles of the* Sphere *are deſcribed, and the neceſſary Terms of Art explained to the meaneſt Capacity, with Reſpect to the diurnal Motion; and that either.*

1. *According to the* Ptolomaick Syſtem, *wherein you have in a* Right-angle Spherical Triangle, *all the Variety of* Queſtions *and* Examples *that relate to the* Sun, *with Reſpect*

to his Longitude, Declination; Right or Oblique Aſcenſion, or Deſcenſion; Riſing, Setting, Amplitude; Altitude and Azimuth, or the Hour of Six; Altitude, Hour of the Day, when Eaſt or Weſt; Hour, Azimuth, and Altitude, when he is in the Equinoctial. *In* 24 Problems. Alſo,

In an Oblique Spherical Triangle, *you have great Variety both with Reſpect to the* Sun *or a* Star, *in many Queſtions and Examples relating to the* Sun's *Altitude, Azimuth, and Hour of the Day, in any Place, at any time of the Year: And relating to a* Star; *as to its Longitude, Latitude, Declination, Right Aſcenſion; Riſing, Setting, Amplitude, Altitude, Azimuth, Hour of the Night, its Altitude on the Meridian, and Time of its coming to it: In* 12 Problems. *Or,*

2. *According to the* Pythagorean, *or* Copernican, Syſtem; *which is now generally received, as moſt agreeable to the obſerved experienced Motion of the Heavenly Bodies; wherein* Spherical Trigonometry *is applied in variety of Queſtions and Examples relating to the* Earth's Diurnal Motion about its own Axis, *once in* 24 *Hours, whereby all the viſible Appearance of the* Sun *and* Fixed Stars *are ſolved, with the Deſcription of the Circles of the* Sphere, *and how they are drawn* Stereographically *on the* Plain *of the* Earth's Ecliptic. *In* 9 Problems.

X. *Then follow very eaſy Rules to find the* Variation of the Compaſs, *and how to rectify the* Compaſs, *and to* Correct the Courſe *thereby, both Arithmetically and Inſtrumentally, with great Readineſs.*

Alſo here you have the way of Projecting the Sphere Orthographical. *In two* Problems, *with many Examples.*

XI. *An Obſervation, either of* Sun *or* Star; *what it is, how or with what, and when 'tis taken; with Rules to find the Latitude of the Place of Obſervation, and all the Varieties therein reduced unto one* Propoſition, *containing two* General Caſes, *fully explained by many Examples,*

XII. *You have next the Uſe of all the foregoing Inſtructions, ſummarily comprehended in a new Form of keeping a* Sea-Reckoning *or* Journal, *wherein the* Log-Book *and* Journal *in Words at Length and Tabular in Figures, are kept together in one Book; whereby the whole Proceed, and every particular Tranſaction of any Voyage at all times may be ſeen and known, which will be no ſmall Satisfaction to thoſe concerned in* Ship *and* Goods, *nor a little Augmentation to the* Mariner's Credit *and* Reputation.

And that ſo uſeful and beneficial a Method might be practiſed by all who deſire to keep a Compleat and Exact Reckoning, and ſo be enabled to render a good Account thereof: I have largely deſcribed the Form and Manner of it, with plain Rules and Directions how to correct the Reckoning by the obſerved Latitude, *and how to find what* Latitude and Longitude the Ship is in every Day; *with an Example of a* Seven Days Journal: *And how each Days Sailing is managed, in taking it from the* Log-Board, *caſting it up, bringing it into one* Courſe *and* Diſtance; *with framing the* Dead-Reckoning, *and ſetting it in the* Journal. *So that by this the Whole is made more inteligible.*

Laſtly, *In the* Tabular Part, *you have firſt, a* Traverſe Table; *which tho' it ſtands in ſo little Room as two Pages, yet by it the* Difference of Latitude and Departure from the Meridian, *may be found for any* Diſtance *under* 10,000, *and for every* Quarter Point of the Compaſs.

Next to that, A Table of Meridional Parts *to every* 5 *Minutes of Latitude, which together with the* Table of Proportional Parts *annexed, the Meridional Parts for each ſingle Minute are found.*

And next adjoining is a Table of 10,000 Logarithms.

After which you have a Triangular Canon Logarithmical, *or a* Table of Artificial Sines, Tangents, and Secants, *to every Degree and Minute of the Quadrant, which are corrected with more than ordinary Care, there being none when this* Book *was firſt* publiſhed *in* 1686, *extant (in this Volumn) that had* Secants *beſides this. The Deſcription and general Uſes of theſe Tables are comprehended in* 4 *Chapters, containing* 13 Propoſitions *and ſet juſt before the* Tables: *At* Page 294.

The Schemes or Figures, are contained in 10 Copper-Plates, *inſerted in their proper Places, being orderly Numbred with proper References for the more eaſy turning to any upon Occaſion.*

Thus have you the Sum of what's here treated, what my Labour and Pains have been herein, I *leave you to judge who are moſt like to reap the Fruit and Profit (my Share being a very ſmall Part) thereof; though I dare aver, it's the* Compleateſt and Portableſt Pile of Inſtructions *for a* Young Learner of Navigation *now extant: It's the very Method I have uſed for now* 50 *Years, finding it ever ſucceſsful even to the moſt indifferent Capacity among the many Hundreds I have* Taught. *Therefore, if my* Reader *would be a* Proficient *herein, let him begin chearfully, and proceed gradually, and the End will crown his Endeavours with anſwerable Succeſs.*

Let not Sloth perſwade to give out at the meeting of any Difficulty, but rather remember that Love, Labour *and* Conſtancy will overcome the greateſt Difficulty. *And,*

That my Learner *may ſo read as to underſtand, and ſo underſtand as to be a* Proficient, *is the Deſire and (where I am preſent is the Endeavour) of him, who wiſheth the* Young Studient's Welfare, *and the* Progreſs *of* Arts.

Near Cherry - Garden-
Stairs *on* Rotherhith Wall, *in*
the 72d *Year of my Age,* 1717.

JAMES ATKINSON.

Epitome

Epitome of the Art of *Navigation.*

CHAP. I.

Practical Geometry explain'd by Definitions, Problems and Proportions.

GEometry is a *Mathematic Science,* explaining the Kinds and Properties of continued Quantity or Magnitude: that is; a Line, a Superficies, and a Solid, whoſe Original is from a Punct.

Section. I. *Of Lineal Geometry, or the firſt kind of Magnitude.*

Definitions 1. A *Punct* or *Point*, is that which cannot be divided into Parts, and is the end of a Mathematical Line: As the Punct A. *Plate* 1. *Fig.* 1.

2. A *Mathematical Line* hath no Breadth, or Thickneſs, only Length; it is made by the moving of a Punct, and (conſidered in it ſelf) is either Regular or Irregular.

3. *Regular* is either a Right Line or an Arch.

4. A *Right Line* is the ſhorteſt diſtance between two Puncts; as the Line BC. *Plate* 1. *Fig.* ~~3~~ 1

5. An *Arch* is not the ſhorteſt diſtance between two Puncts, but bendeth evenly: As the Arch DE.

6. *Irregular* is any crooked Line that bendeth unevenly: as FG. *Plate* 1. *Fig.* 1.

7. *Lines* compared, are either parallel, or inclining; from whence proceed many Problems.

Problem I. *To draw a Line parallel to a given Line*

Definition. P*Arallel Lines,* are of equal Diſtance, and if infinitely produced, (being in the ſame Superficies) will never meet: as the Lines AB and CD. *Plate* 1. *Fig.* 2.

Example. AB the Line } given.
C is a Punct }

Through which Punct C, and parallel to the Line A B, a Line is required to be drawn.

1. Take (with a pair of Compaſſes) the neareſt Diſtance between the given Punct C, and the Line AB.

2. With that Diſtance (in the Compaſſes) and one Foot of the Compaſſes (any where in the Line A B,) draw (that way the Punct C lieth) an Arch D.

3. From the Punct C, draw a Line to touch the Arch D, and it's done, for the Line CD, is parallel to the Line AB, as was required.

Problem II. *To biſect or divide a given Line into two equal Parts,*

Example. AB is a given Line. *Plate* 1. *Fig.* 3.
To find the middle thereof is required.

1. WIth any Diſtance, (greater than half the given Line AB) and one Foot of the Compaſſes on A, deſcribe the Arch CD.

2. With the ſame Diſtance, and one Foot on B, croſs the former Arch in C and D.

3. By C and D draw a Line which will cut AB in E, the middle; and if AB is equal to EB, it's done true; which point E is the middle of the Line AB, as was required.

Prob. III. *To erect a Perpendicular from a Punct in a given Line.*

Definitions 1. INclining *Lines*, are not of equal Diſtance, and if produced, will meet: as the Lines AB, and CD. *Plate* 1. *Fig.* 4.

2. The meeting of Inclining Lines, (called an Angle) is either Direct or Oblique.

3. *Direct-meeting* of Lines, is when the Angles on each Side are equal: as EGF, and GH; and this kind of meeting is called Perpendicular. *Plate* 1. *Fig.* 4.

Example. AB is a Line given.

The Punct A one end of it, from whence to erect a Perpendicular is required. As *Plate* 1. *Fig.* 5.

1. With any Diſtance, and one Foot in A, draw an Arch to cut the Line AB in D.

2. With the ſame Diſtance, and one Foot in D, draw an Arch to cut the former Arch in C.

3. With the ſame Diſtance, and one Foot in C, deſcribe an Arch DE, to cut the Line AB in D.

4. By C and D draw a Line, to cut the Arch DE in E.

5. Then by A and E draw a Line, and it's done: For the Line AE is perpendicular unto AB, as was required.

Prob. IV.

Problem IV. *To let fall a Perpendicular, from a given Punct to a given Line.*

Example. AB is a Line given; C is a given Punct: From whence to let fall the Perpendicular to the Line AB is required. *Plate* 1. *Fig.* 6.

1. Draw a Line (at pleaſure) from C to AB, as is the Line CD.

2. By Prob. 2. biſect the Line CD in E.

3. With the Diſtance EC, equal to ED, and one Foot in E; croſs the Line AB in A.

4. By A and C draw a Line, and it's done: For AC is a Perpendicular let fall from the Punct C, to the Line AB as was required.

Prob. V. *To make a Plain Angle.*

Definitions 1. The meeting of inclining Lines is called an Angle, and the Lines ſo meeting are called Sides of the Angle; as AB and AC. *Plate* 1 *Fig.* 7.

2. An *Angle* is either a Right Angle, or an Oblique Angle.

3. A *Right Angle* is where two Lines are perpendicular to each other: as ED and DF, *Plate* 1. *Fig.* 7.

Note, A *Right Angle,* is juſt 90 Degrees.

4. An *Oblique Angle,* is either Acute leſs than 90; as BAC, or Obtuſe more than 90 degrees; GHI in *Fig* 1. *Plate* 7.

Note; An Angle is written with 3 Letters, the middle Letter ſignifieth the angular Punct: as BAC ſignifieth the Angle A.

An *Angle* is meaſured by an *Arch,* whoſe Center is the angular Punct, and is drawn from one Side to the other of the Angle, as the meaſure of the Angle KLM is the Arch NO, *Plate* 1. *Fig.* 7.

What a Degree is you may ſee in *Prob.* 9. *Definition* 1.

Example 1. At A in the Line AB, to make a Right Angle, *Plate* 1. *Fig.* 7.

The Rule. Upon A (by *Prob.* 3.) erect the Perpendicular AC, and it's done: for the Angle BAC is a Right-angle.

Example 2. At A in the Line AB, to make an Acute Angle equal to 41 degrees. *Plate* 1. *Fig.* 8.

1. Take (always) a Chord of 60 Degrees from your Scale, and with one Foot on A draw an Arch DE, to cut the line AB in D.

2. Make the Arch DE equal to the Chord of 41 deg. that is, take 41 deg. from the ſame Scale of Chords, and lay it on the Arch from D to E.

3. By A and E draw the Line AEC, and it's done: for the Angle BAC is an Acute Angle, containing 41 degrees.

Example 3. At B in the Line BC, to make an Obtuſe Angle equal to 102 degrees. *Plate* 1. *Fig.* 8.

1. As before (with one Foot on B) draw the *Arch* EF with a Chord of 60 deg. to cut BC in E.

2, On that Arch make EG equal to GF, and each equal to 51d. the half of 102d. that is, take 51d. from the ſame *Scale of Chords*, and lay it on the Arch from E to G, and from G to E.

3. By B and F draw the Line BFD, and it's done; for the Angle CBD is an Obtuſe Angle, containing 102 Degrees.

Sect. II. *Of Superficial Geometry, or the Second kind of Magnitude.*

Definitions. 1. A Superficies hath no Thickneſs, only Length and Breadth, it's made by the Moving of a Line; and is either plain, convex, or concave.

2. A plain Superficies, is a Figure flat, ſmooth, and even, made by the Motion of a Righ-tline; it's either *ſimple* or *variout.*

3. A *ſimple* / *various* *Figure* or *Superficies* is bounded by oneLine / Lines

4. A *Figure* bounded by one Line, is either a Circle or an Ellipſis,

5. A *Figure* bounded by Lines, is either a Triangle, a Quadrangle or a Multangle.

6. In every Superficies there are three things to be noted.

1. The *Term*, which is that Line, or Lines bounding it; as BCDEB. *Plate* 1 *Fig.* 9.

2. The *Center*, which is a Punct in the middle of it; as A.

3. The *Area*, which is all the Space contained within the Term, as ABCDEBA. *Plate* 1 *Fig.* 8.

7. The kinds of Plain Figures are ſeven, a *Circle*, a *Triangle*, a *Quadrangle*, and a *Multangle*, the moſt eaſy to make: the more difficult are the *Ellipſis*, *Parabola*, and *Hyperbola*: each affords divers *Problems*, of which we begin with the Circle.

Prob. VI. *To deſcribe a Circle, having its Diameter given.*

Definitions 1. A *Circle* is a plain Figure bounded by one Line, called the Periphery: As ABCDEBA. *Plate* 1. *Fig.* 9

2. The *Periphery* of a Circle, is a Line compaſſing it; ſo that it's equally diſtant from the Center: as BCDEB.

3. The *Center* of a Circle is a Punct in the middle of it, from whence all Right Lines drawn to the Periphery are equal, and call'd Radius: As A.

4. The *Diameter of a Circle*, is any Right-line drawn through the *Ceneer* to the *Periphery*; it biſecteth the Circle, and is the longeſt Right-line can be drawn in it; as BAD is a Diameter.

Example. BD equal to 60 Inches is given; to make a Circle on or about it, is required. *Plate* 1. *Fig.* 10.

1. Biſect by (by *Prob.* 2.) the Line BD in A.

2. With the Diſtance AB equal to AD, and one Foot on A. deſcribe the Periphery BCDEB, and it's done.

Prob.

Prob. VII *To draw the Periphery of a Circle through any three Puncts not in a Right Line.*

Example. B, C, and D, are three Puncts given, through them to draw the Periphery of a Circle is required. *Plate* 1. *Fig.* 11.

1. With any Diſtance (greater than half CB, or CD) and one Foot in C draw an Arch FGHI.

2. With the ſame Diſtance, and one Foot in B, croſs that Arch in F and G.

3. Likewiſe (with the ſame Diſtance and) one Foot in D, cut the former Arch in H and I.

4. By F and G, and H and I, draw Lines to cut each other in A the Center.

5. With the Diſtance AB, equal to AI, equal to AD, and one Foot on A, draw the Periphery BCDB, and it's done.

Prob. VIII. *To quarter a Circle, or in a Circle to draw two Diameters at Right Angles.*

Example. BCDEB the Periphery, and A the Center of the given Circle. In which to draw two Diameters at Right Angles is required. *Plate* 1. *Fig.* 12.

1. Through the Center A, draw the Diameter BAD.

2. Biſect (by *Prob.* 2.) B A D, by drawing the Line C A E, and it's done. And if BC, CD, DE, and EB are equal to each other, it's done true ; otherwiſe not.

Prob. IX. *To find the Chord, Sine, Tangent, and Secant of an Arch of a Circle.*

Definitions 1. If the *Periphery* of a Circle be divided into 360 equal Parts, they are Degrees ; a Degree divided into 60 equal Parts, are Minutes ; a Minute into 60 equal Parts, are Seconds, &c. *Plate* 1 *Fig.* 13.

2. The Arch of a Circle is any part of the Periphery ; as EB, or EBF ; and is counted in Degrees, which are greater or leſſer in Proportion to the Radius of the Circle.

3. *Radius* of a Circle is half its Diameter, or any Right-line drawn from the Center to the Periphery : As AB.

4. A *Chord-line* is drawn from one end of an Arch to the other ; as EDF, or EB, are Chord-lines.

5. A *Sine-line* is half a Chord-line of double the Arch : as ED (being half the Chord EDF) is Sine of the Arch BE; and DF the Sine of BF.

6. A *Verſed Sine-Line* is between the Sine-line and the Periphery, as DB is Verſed Sine of the Arch BE

7. *Tan*

7. *Tangent* toucheth the Periphery, and is perpendicular to a Diameter in the touch Punct: as BC is a Tangent Line of the Arch B E.

8. *Secant* cutteth the Periphery, being drawn from the Center till it meet the Tangent: as *AC* is Secant of the Arch *BE.*

Example. The Chord, Sine, Tangent, and Secant of 45 deg. is required. *Plate* 1. *Fig.* 13.

1. With any Diſtance (and one Foot on A) deſcribe the Periphery *HI B G.*

2. Quarter the Periphery (by Prob. 8) by drawing the two Diameters *HAB* and *IAG* ; then is *BG* equal to *GH*, equal to *H I*, equal to *IB*, equal to 90 degrees.

3. Divide (by Prob. 2.) *B I* into two equal parts in E, and then *BE* equal to *E I* is equal to 45 degrees.

4. Make *B F* equal to *B E*, and draw the Lines *B E*, and *EDF*, to cut the Diameter *HAB* in *D.*

5. At *B* (by Prob. 3.) erect *B C* perpendicular to the Diameter *H AB*; or draw (by Problem 1.) *BC* parallel to the Diameter *IAG.*

6. By *A* and *E* draw a Line to cut *B C* in *C*, and it's done.

Then the Line *B E* is the Chord of 45 deg. the Line *E D F* the Chord of 90 deg. the Line *E D* equal to *DF*, the Sine of 45 deg. *DB* the Verſed Sine, *BC* the Tangent Line, and *AC* the Secant Line of the ſame Arch *B E*, equal to 45 deg

This Problem is the Ground-work of the Line of Rumbs, Chords, Sines, Tangents. Secants, *&c.* Set on Rulers called Scales: As alſo of the Degrees on the Quadrant or Croſs-Staff, and other Mathematical Inſtruments.

But its chiefeſt Uſe is in a Right Angled Triangle, as ſhall be ſhewed in Trigonometry, when I come to explain the firſt *Axiom* in making any ſide *Radius*, to which you are referr'd.

Of Triangles the 2d *Kind of Plain Figures.*

Definition 1. A *Triangle* is any three corner *Figure*, having three *Sides* and three *Angles*, as *ABC* ; and in Reſpect of its *Angles*, is either Rectangular or Obliquangular. *Plate* 1. *Fig.* 14.

2. A *Right-Angle Triangle* hath one *Right-Angle*; in its making hath a Perpendicular erected, or let fall: as *ABC.*

3. Thoſe Sides containing the Right-Angle, are called Legs: as Leg *AB*, and Leg *BC.* *Plate* 1. *Fig.* 14.

4. The Side oppoſite to the Right Angle is called the Hypothenuſe: as *A C.* *Plate* 1. *Fig.* 14.

Prob. X.

Prob. X. *To make a Right Angle Triangle, the Hypotenuſe, and one Angle given.*

Note 1. The three Angles of every Plain Triangle (together) are equal to 180 Degrees.

2. To make a Right Angle Triangle, two Things (beſides the Right Angle) and one a Side, muſt be given.

Example. The $\left\{\begin{array}{l}\text{Hypotenuſe } AC \text{ 137 Feet}\\ \text{Angle } BAC \text{ 34d 30m.}\end{array}\right\}$ given.

With them to make a Right Angle Triangle is required *Plate* 1, *Fig.* 15.

1. Make the Angle *BAC* equal to 34d. 30m. (by *Prob.* 5. *Examp.* 2.) that is take a Chord of 60d. and with one Foot on A, draw an Arch, and on that Arch lay the Chord of 34d. 30m. drawing *AB* and *AC*, which includes the Angle *BAC* equal to 34d. 30m.

2. Make AC equal to 137 Feet; that is, from any Scale of equal Parts take 137, and lay it from *A* to *C*.

3. From C (by *Prob* 4) let Fall the Perpendicular *BC*, to cut the Line *AB* in *B*, and it's done.

Prob. XI. *To make a Right Angle Triangle; the Hypotenuſe and one Leg given.*

Example. The $\left\{\begin{array}{l}\text{Hypotenuſe } AC \text{ 411}\\ \text{Leg } AB \text{——— 342}\end{array}\right\}$ Perches given.

With them to make a Right Angle Triangle, is required. *Plate* 1 *Fig* 16.

1. Make *AB* equal to 342 Perches; that is, from any *Scale* of equal Parts take 342, and lay it from *A* to *B*.

2. At *B* (by *Prob.* 3.) erect a Perpendicular *BC*.

3. With 411 Perches: (That is; take 411 from the ſame Scale of equal Parts, the 342 was taken) and with one Foot cut the Perpendicular in *C*.

4 From *A* to C draw a Line and it's done.

Prob. XII. *To make a Right Angle Triangle, one Leg and one Angle given,*

Example. The $\left\{\begin{array}{l}\text{Leg } AB \text{ 415 Miles}\\ \text{Angle } BAC \text{ 40d. 25m}\end{array}\right\}$ given;

With them to make a *Right Angle Triangle* is required by *Plate* 1. *Fig.* 17.

1, Make *AB* equal to 415 Miles, that is, from any *Scale of*

Equal Parts, take 415, and lay it from A to B. And at B (by Prob. 3.) erect a Perpendicular BC.

2. At A (by Prob. 5. Example 2.) make the Angle BAC equal to 40d. 25m. (which is thus; take a Chord of 60d, and with one Foot on A, draw an Arch, on which Arch lay the Chord of 40d. 25m.) by drawing the line AC, and it's done.

PROB. XIII. *To make a Right Angle Triangle, the Legs given*

Example. The Leg $\left\{\begin{array}{l}\text{AB } 404\\ \text{BC } 328\end{array}\right\}$ Leagues given.

With them to make a Right-Angle Triangle, is required. *Plate* 1. *Fig.* 18.

1. Make AB equal to 404 Leagues. And at B (by Prob. 3.) erect a Perpendicular BC.

2. Upon the Perpendicular, make BC equal to 328 Leagues, and from A to C draw a Line and it's done.

Of Oblique-angle Triangles.

Definition 1. An Oblique Triangle hath three Oblique Angles, and is either an Obtuſe or an Acute Triangle.

2. An Obtuſe Triangle hath one Obtuſe Angle, that is, one Angle more than 90d, as BCD. *Plate* 1, *Fig.* 19.

3. An Acute Triangle hath all its three Angles Acute; that is, each Angle is leſs than 90d. as EFG. *Plate* 1. *Fig.* 19.

Note; To make an Oblique Triangle, three things, (and one of them a Side) muſt be given.

Prob. XIV. *To make an Oblique Triangle, two Angles and one ſide oppoſite given.*

Example. The $\left\{\begin{array}{l}\text{Angle}\left\{\begin{array}{l}\text{BCD } 114\text{d.}\\ \text{BDC } 26\text{d. } 40\text{m.}\end{array}\right.\\ \text{Side BC } 352 \text{ Miles.}\end{array}\right\}$ given.

With them to make an Oblique Triangle is required. *Plate* 1. *Fig.* 19.

1 Make BC equal to 352 Miles. And at C (by Prob. 5. Examp. 3.) make the Angle BCD equal to 114d. by drawing the Line CD: That is, Take a Chord of 60d. and with one Foot on C, draw an Arch. on that Arch lay the Chord of 114d. by taking its half 57d. and laying it twice on the Arch, by which draw the Line CD, thereby you'll conclude the Angle BCD 114 Degrees.

2. Add 114d. and 26d. 40m. its 140d. 40m. the Sum of the given Angles. Which ſubtract from 180d 00m. the Sum of the Three Angles. ————
Remainder is the Angle CBD ———— 39d. 20m.

3. At B (by *Prob.* 5. *Example* 2.) makes the Angle CBD equal to 39d. 20m. by drawing the Line BD: That is, with a Chord of 60d. and one Foot on B, draw an Arch on that Arch, lay the Chord of 39d. 20m. by which draw the Line BD, and it's done.

Prob. XV. *To make an Oblique Triangle, two Sides and one Angle oppoſite given.*

$$\textit{Example.}\ \text{The}\left\{\begin{array}{l}\text{Side}\left\{\begin{array}{l}\text{BC}\ \ 274\\ \text{BD}\ \ 426\end{array}\right\}\text{Miles}\\ \text{Angle BCD 108d. 30m.}\end{array}\right\}\text{given.}$$

With them to make an oblique Triangle is required, *Plate* 1, *Fig.* 20.

1. Make BC equal to 274 Miles, and at C (by *Prob.* 5. *Exam.* 3.) make the Angle BGD equal to 108d. 30m. by drawing the Line CD.

2. With 426 Miles and one Foot in B, cut the Line CD in D, and by B and D draw a Line and it's done.

Prob. XVI. *To make an Oblique Triangle, Two Sides, and an included angle given.*

$$\textit{Example}\ \text{The}\left\{\begin{array}{l}\text{Side}\left\{\begin{array}{l}\text{BC}\ \ \ 327\\ \text{BD}\ \ \ 274\end{array}\right\}\text{Feet}\\ \text{Angle CBD 101d. 30m.}\end{array}\right\}\text{given.}$$

With them to make an Oblique Triangle is required, *Plate* 1. *Fig.* 21.

1. Make the Side B C equal to 327 Feet. And at B (by *Prob.* 5. *Examp.* 3.) make the Angle CBD equal to 101d. 30m. by drawing the Line BD.

2. Make BD equal to 274 Feet; and by C and D draw a Line, and it's done.

Prob. XVII. *To make an Oblique Triangle, three ſides given.*

Note; Any two Sides muſt be greater than the Third, to make a Triangle.

$$\textit{Example.}\ \text{The Side}\left\{\begin{array}{l}\text{BD}\ \ 525\\ \text{BC}\ \ 425\\ \text{CD}\ \ 250\end{array}\right\}\text{Leagues given.}$$

With them to make an Oblique Triangle is required, *Plate* 1. *Fig.* 22.

1. Make BD equal to 525 Leagues. Then with 425 Leag and one Foot in B draw an Arch C.

2. With 150 Leagues and one Foot in D, cut the Arch in C, and from C draw Lines to B, and to D, and its done.

Sect III. *Of Proportions for ready meaſuring Superficies and Solids.*

HAving ſhewed the making the moſt common and uſeful *Geometrical Figures*, I now proceed to their (and others) Menſuration, by exact and eaſy Rules.

Now to prevent the Book's ſwelling too great, I'll not trouble you with Arithmetical Calculation, but preſent you with an Inſtrumental way of Operation, that's quick and true, eaſy and ready, on *Gunters-Scale*, an Inſtrument ſo very well known, it needs the leſs Deſcription: only to avoid Repetitions take this excellent Rule.

A General Rule for Gunter's-Scale.

Extend the Compaſſes from the firſt Term (in a Geometrical Proportion) to the ſecond; that Extent (if rightly laid) from the third, will reach the fourth Term, or thing required.

This Rule well minded, will make what follows appear eaſy, and ſave many Words and much Time; and therefore to explain it, take this Proportion.

As 2 is to 6, ſo is 5 to 15; which I ſhorten thus;

2 .. 6 : : 5 .. 15.

The Extent (on the *Line of Numbers*) from 2 unto 6, (according to the ſaid *General Rule*) will reach from 5 unto 15 the fourth Term and thing required.

Theſe Words may be ſpared by the ſhort Way of writing the Proportion and minding the Order of the Terms, as in the Problems following. *But for a full Explanation of the* Gunter, *and how to work any Proportion by it, ſee my Additions to Mr.* WAKELEY's MARINER's COMPASS RECTIFIED. Page 181, *&c.*

Prob. XVIII. *The Diameter of a Circle given; to find its Periphery.*

The Rule. As $\left\{\begin{matrix}7.\\1\end{matrix}\right\} .. \left\{\begin{matrix}32\ \text{——}\\3.14159\end{matrix}\right\}$: : Diameter .. Periphery.

Example. The Diameter 34 Inches: what is the Periphery?

Anſw. Inches 106.8 Tenths of an Inch. For,

As $\left\{\begin{matrix}7\\1\end{matrix}\right\} .. \left\{\begin{matrix}22\ \text{——}\\3.14\end{matrix}\right\}$: : 34 Inches .. 106.8 tenths.

That is, The Extent of the Compaſſes (on the *Line of Numbers*) from 7 to 22, or from 1 to 3.14, *&c.* will reach from 34 Inches to 106.8 Inches neareſt. Obſerve the like in all the reſt.

Prob. XIX. *By the Periphery to find the Diameter?*

The Rule. As $\left\{\begin{array}{l}22\text{———}\\3.14159\\1.\text{———}\end{array}\right\} .. \left\{\begin{array}{l}7.\text{———}\\1.\text{———}\\0{,}3183\end{array}\right\}$: : Periph. .. Diamet.

Examp. Periphery Inches 106.8 tenths, what is the Diameter. *Anſwer*, Inches 34. For 22 .. 7 : : Inches 106·8 .. 34 Inches the Diameter required.

Prob. XX. *The Diameter of a Circle given; to find its Area or Content.*

The Rule.
1. Find its Periphery by *Prob.* 18. Then ſay,
2. As 1 .. $\frac{1}{2}$ Diameter : : $\frac{1}{2}$ Periphery .. Area.

Examp. The Diameter 14 Inches; what is its Area? *Anſw.* 154 Inches.

By *Prob.* 18. The Diameter being 14, the Periphery is 44 Inches, and by the Rule it is thus:

As 1 .. 7 : : 22 .. 154 Inches the Area or Content required.

Prob. XXI. *By the Periphery to find the Area.*

The Rule
1. Find the Diameter by *Prob.* 19. And then
2. The Area is found by *Prob.* 20.

Examp. The Periphery 22 Feet: What is the Area? *Anſw:* Feet 38 5 Tenths.

The Periphery 22 Inches, the Diameter is 7 Inches, by *Prob.* 19.

And by *Prob.* 20, it is thus, As 1 .. 3.5 : : 11 .. Inches 38.5, the Area required.

Note, The Area is of the ſame Name with the Dimenſions taken: That is; if the Diameter and Periphery be Inches, Feet, or Yards, *&c* then the Area is Inches, Feet, or Yards, *&c.*

Prob. XXII. *To reduce the Area or Content of any thing found in Inches, to Feet; or to Gallons, Beer or Wine.*

1. *Rule for Feet; ſay,* 144 .. 1 : : Area in Inch. .. Area in Feet
2. *Rule for Gallons.* As $\left\{\begin{array}{l}282\\231\end{array}\right\}$ .. 1 : : Area in Inches .. $\left\{\begin{array}{l}\textit{Beer}\\\textit{Wine}\end{array}\right\}$ Gallons

This needs no *Example*; and to avoid the *firſt Rule*, take the Dimenſions in *Foot-meaſure*; that is, 12 *Inches*, or a *Foot* divided Decimally: That is, into 100 equal Parts, called the *Line of Foot-meaſure.*

Prob. XXIII. *The Diameter, or Periphery of a Circle given, to find the ſide of the inſcrib'd ſquare, or the Chord of* 90 deg.

The Rule. As 1 ·· $\left\{\begin{matrix}.707\\ .225\end{matrix}\right\}$ :: $\left\{\begin{matrix}\text{Diamet.}\\ \text{Periph.}\end{matrix}\right\}$ ·· *Side* of the inſcribed Square, or Chord of 90d. required.

Example. The Diameter of a Circle being Feet 3.4 Tenths; What is the Side of the inſcribed Square, or the Chord of 90 degrees? *Anſw. Feet* 2.4038 parts of 100.

For; As 1 ·· 0.707 : : 3.4 ·· 2.4038 the Chord of 90 deg. or Side of the inſcribed Square.

Prob. XXIV. *The Baſe and Perpendicular of a Triangle given; to find the Area.*

The Rule. As 1 ·· $\frac{1}{2}$ Baſe : : perpendicular ·· Area required.

Examp. The Baſe 16 Inches, and the Perpendicular 12 Inches: I demand the Area? *Anſw. 96* Inches.

For; As 1 ·· 8 : : 12 ·· *96* the Area required.

Prob. XXV. *The Length and Breadth of a Parallelogram given; to find its Area.*

Definition. 1. A Quadrangle hath four Angles, and four Sides as ABCD; and is either a Parallelogram or a Trapezia. *Plate* 1. *Fig.* 23.

2. A *Parallelogram* hath its oppoſite ſides Parallel and equal as ABCD; and is either a Square, a Long-ſquare, a Rhombus, or Romboide; the firſt two are Rectangle Parallelograms, the latter are Obliquangled Parallelograms.

3. A *Square* hath four equal Sides, and four equal Angles: as ABCD. *Fig.* 23.

4. A *Long-ſquare*, hath but two Sides equal, and four equal Angles; As EFGH. *Fig.* 24

5. A *Rhombus*, hath four equal Sides, and but two oppoſite Angles equal; as IKLM. *Fig.* 25.

6. A *Rhomboids*, hath only two oppoſite Sides, and two oppoſite Angles equal; as NOPQ *Fig.* 26.

Note, The Breadth of the two laſt is not IM nor NQ; but the Perpendicular MN, and QR, and to meaſure all Parallelograms, obſerve this *General Rule.*

As 1 ·· Breadth : : Length ·· Area required.

Examp. 1. A Square whoſe Length AB, and Breadth BC, each is Feet 2.5 tenths: What is the Area? *Anſw.* Feet 6.25 parts of 100. For; As 1 ·· 2.5 :: 2.5 ·· 6.25 Area, *Fig.* 23.

Examp. 2. A Long-ſquare, whoſe Length EF, is Feet 2.5, and Breadth FG is Feet 1.6: What is the Area? *Anſw.* 4 Feet For; As 1 .. 1.6 :: 2.5 ·· 4 Feet Area. *Plate* 1. *Fig.* 24.

Examp. 3. A Rhombus whoſe Length IK is Feet 2.5, and Breadth MN Feet 1.6: What is the Area? *Anſw.* Feet 4. *Plate* 1. *Fig.* 25.

For; As 1 ·· 1.6 :: 2.5 ·· 4 Area required.

Examp. 4. A Rhomboids whoſe Length NO is Feet 25, and Breadth QR Feet 12. What is its Area? *Anſw.* 300. For, As 1 ·· 12 :: 25 ·· 300 Area required. *Plate* 1. *Fig.* 26.

Prob. XXVI. *The Diagonal and two Perpendiculars of a Trapezia given; to find its Area.*

Definition 1. A *Trapezia*, hath its oppoſite ſide and its oppoſite Angles unequal: As ABCD. *Plate* 1. *Fig.* 27.

2. The *Diagonal*, is a Line drawn from its oppoſite Angles; as AC.

3. The Two Perpendiculars, are let fall from the Angles to the Diagonal, As BE, and DF.

The Area of a Trapezia, if found by this Rule.

As 1 ·· $\frac{1}{2}$Diagonal :: Sum of the Perpendiculars ·· Area req

Examp. The Diagonal AC 28 Feet; The Perpendicular BE 15 Feet; and DF 12 Feet: What is it's Area? *Anſw.* 378 Feet

For; As 1 .. 14 :: 27 ·· 378 *Feet* the Area required. *Plate* 1. *Fig.* 27.

Prob. XXVII. *The Length and Breadth of an Ellipſis called an Oval given, to find the Area,*

The Rule.

As 1 ·· Breadth :: Length ·· 4th Number: then ſay again.

$$\text{As}\left\{\begin{matrix}14\\1\end{matrix}\right\}\cdot\cdot\left\{\begin{matrix}.11\text{———}\\.78539\end{matrix}\right\}::\text{4th Number}\cdot\cdot\text{Area required.}$$

Examp. The Tranſverſe Diameter of an Ellipſis 12 *Feet*, and Conjugate Diameter 8 *Feet*. What's the Area? *Anſw.* 75.$\frac{4}{6}$ *Feet.*

For ·· As 1 ·· 8 :: 12 ·· 96 the Fourth Number.

Then As 14 ·· 11 :: 96 ·· 75.4 the Area required.

Prob. XXVIII. *To find the Area of a Parabola.*

The Rule. As 1 ·· Axe :: Double Ordinate .. 4th Number; Then ſay again As 3 .. 2 :: 4th Number ·· Area required.

Examp. The Axe of a Parabola 9 *Feet*, and the Double Ordinate 8 *Feet*. What's the Area? *Anſw.* 48 *Feet.*

For ;—As 1 ·· 9 : : 8 ·· 72 the 4th Number.
And then ;—As 3 ·· 2 : : 72 ·· 48 Feet the *Area* required.

Sect. IV. *Of Solids, the third kind of Magnitude.*

Definition. A *Solid*, hath Length, Breadth and Depth; and if, bounded by one *Superficies*, is either a *Sphere*, or a *Spheriod* ; but bounded by more than one *Superficies* is either a *Priſm*, a *Pyramid*, a *Priſmoid*, or a *Pyramidoid*; or compounded of the laſt, called a *Spindle.*

Prob. XXIX. *The Diameter of a Sphere given, to find the Solid Content.*

Definition. A *Sphere* or *Globe*, is a *Round Solid*, whoſe Length, Breadth and Depth, is a-like and equal ; being made by the *Rotation*, or moving of a *Semi-Circle* about its *Diameter* ; whoſe *Solid Content* is found by this Rule.

As $\left\{\begin{matrix}21\\1\end{matrix}\right\} \cdot\cdot \left\{\begin{matrix}11 \cdot\cdot \cdot\cdot\\ .523599\end{matrix}\right\} ::$ *Cube of Diam* ·· *Cont.* required.

Example. A *Sphere* whoſe Diameter is Feet 2.42 Par s : What's the *Solid Content* ? *Anſw.* Feet 7.43 Parts of 100.

For ; --As 1 ·· 2.42 : : 2.42 ·· 5.86 :: 5.86 ·· 14.17 the *Cube of the Diameter* ; then, *Feet.*

As $\left\{\begin{matrix}21\\1\end{matrix}\right\} \cdot\cdot \left\{\begin{matrix}11\\ 0.524\end{matrix}\right\} ::$ 14.17 ·· 7.43 the *Content* required

In ſuch Caſes as this the readieſt Way is to extend the Compaſſes from the firſt Term to the Third Term ; and that being turned over three Times from the Second Term will reach the Thing required.

As here, the Extent from 1 to the *Diameter* 2.42, turned three Times from 0.524, *&c.* reacheth to *Feet* 7.43 Parts of 100, the Content required. For it's Thus ;

1 ·· 2.42 :: 0.524 ·· 1.27 : : 1 27 ·· 3.07 : : 3.07 7.43 that is,

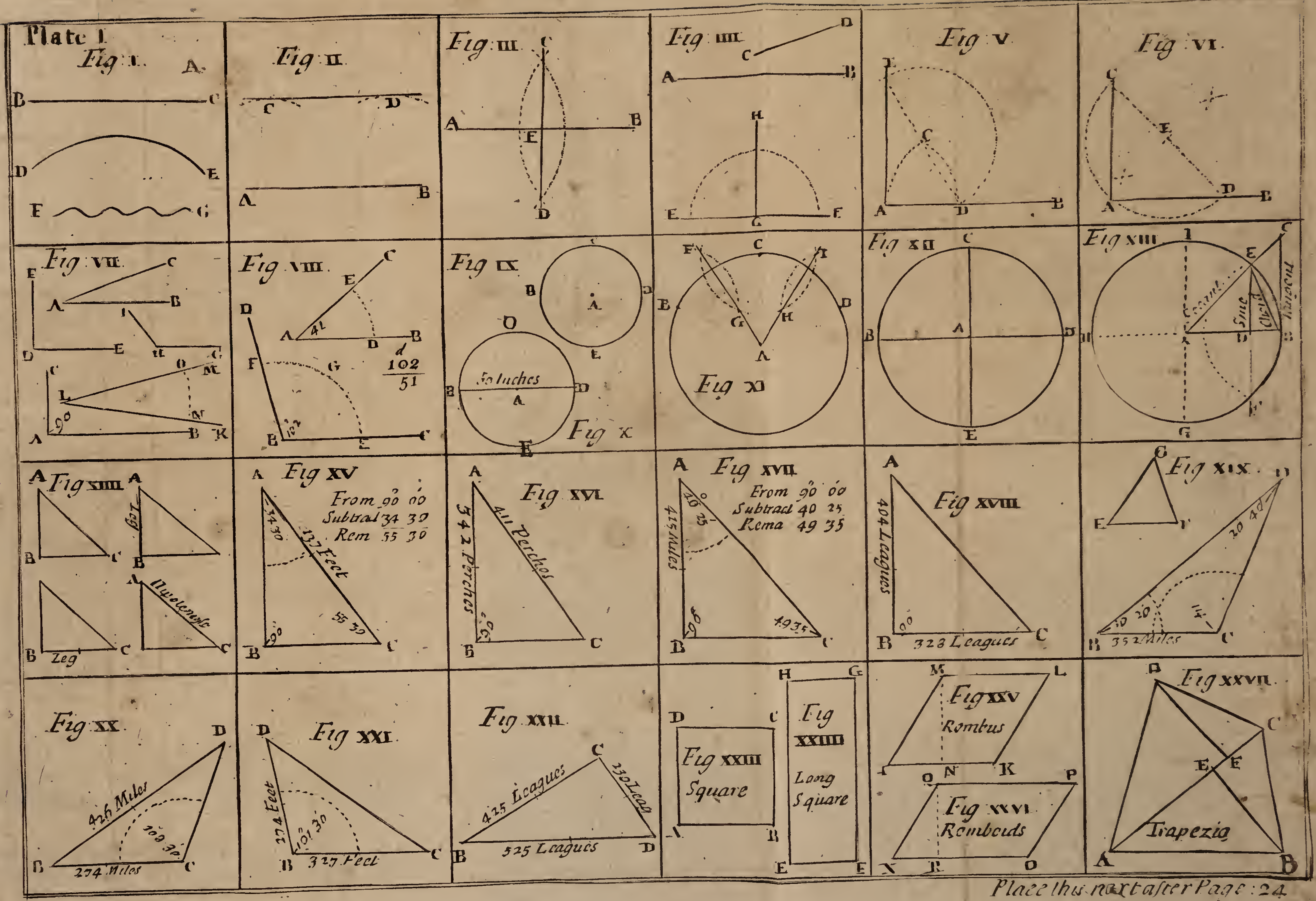
The Extent from 1 to 2.42 (on the *Line of Numbers*) will reach from 0.524 to 1.27 ; and the ſame Extent will reach from 1.27 to 3.07 ; and the ſame Extent from 3.07 reacheth to Feet 7.43 *Parts* of 100.

Prob. XXX. *The Diameters of a Spheriod given ; to find the Solid Content.*

Definition. A *Spheriod*, is an *Oval Solid*, *Longer* than it is *Broad*, or *Deep* ; being made by the *Rotation* of a *Semi-Ellipſe* about its Diameter ; the *Solid Content* is found by this

Rule.

Plate I.



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Rule. As 1 : *Square of Depth* : : *Length* .. a 4th *Numb*, then ſay,

As $\left\{\begin{matrix}21\\1\end{matrix}\right\}$ .. $\left\{\begin{matrix}11.\\.524\end{matrix}\right\}$: : 4th *Number* .. *Content* required

Examp. A *Spheriod* whoſe

$$\left.\begin{array}{l}\text{Length or Tranſverſe}\\ \text{Depth or Conjugate}\end{array}\right\}\textit{Diameter}\text{ is }\textit{Inches}\left\{\begin{array}{l}7.2\\4.1\end{array}\right\}\textit{Tenths}$$

What's the *Solid Content?* *Anſw.* Inches 63.4 Tenths.

For it's; As 1 .. *Square* 4.1 : : 7.2 .. 121 ; here the Extent from 1 to 4.1 is turned twice from 7.2, and it reacheth 121. Then ſay,

As $\left\{\begin{matrix}21\\1\end{matrix}\right\}$ .. 121 : : $\left\{\begin{matrix}11.\\.524\end{matrix}\right\}$ .. | *Inches* 63.4 *Tenths*, the Contents required.

Or thus; As 1 .. 4.1 : : 0.524 .. 2.15 : : 2.15 .. 8.81; That is, the Extent on the *Line of Numbers* from 1 to 4.1 will reach from 0.524 to 2.15 ; and the ſame Extent from 2.15 to S.81 Parts of 100.

Then; As 1 .. 8.81 : : 7.2 .. 63.4; That is, the Extent from 1 to 8.81, will reach from 7.2 to *Inches* 63.4 *Tenths* of an Inch, the Content required.

Prob. XXXI. *The Dimenſions of a Priſm given; to find the Solid Content.*

Definition. 1. A *Priſm*, is a Strait Solid, whoſe two Baſes or Ends, are equal. parallel, a-like, and a-like ſituate.

2. A *Priſm*, takes its *Sir-Name* from its *Baſe*; as a *Round Priſm*, a *Triangular*, a *Quadrangular*, or a *Multangulat Priſm*, all are meaſured by this one *General Rule.*

As 1 .. *Area of one Baſe* : : *Length* .. *Solid Content.*

Examp. 1. A *Round Priſm* called by ſome a *Cylinder*, whoſe

$$\left.\begin{array}{l}\textit{Diameter}\text{ at each End is} \text{ ——— } 21\\ \text{And Length is} \text{ ——————— } 30\end{array}\right\}\textit{Inches}$$

What's the *Solid Content?* *Anſw.* 10392 Inches.

A *Cylinder's two Baſes* are *two equal Circles*, and therefore the *Area* of its Baſe is found by *Prob.* 20. to be *Inches* 346 4 *Tenths*: Then it is,

As 1 .. 346.4 : : 30 .. 10392 *Inches*, *Content* required.

Examp. 2. An *Elliptick Priſm*, whoſe *Baſes* being equal *Ellipſes*, their

$$\left.\begin{array}{l}\text{Tranſverſe}\\ \text{Conjugate}\end{array}\right\}\textit{Diameter}\text{ is }\textit{Inches}\left\{\begin{array}{l}12.\\8.\end{array}\right.$$

And *Length* of the *Solid* is *Inches* 30

What's the *Solid Content?* *Anſw.* Inches 2262.

For its Baſe being an Ellipſis, the Area by *Prob.* 27. is 75.4, Inches, and then it is.

As 1 ·· 75.4 :: 30 ·· 2262 Inches the Solid Content required

Examp. 3. A Trianglar Priſm, who Baſes are two equal Triangles, in each of which

$$\text{The}\left\{\begin{array}{l}\text{Baſe ———}\\ \text{Perpendicular}\end{array}\right\}\text{is Inches}\left\{\begin{array}{l}16.\\ 12.\end{array}\right.$$

And the Length of the Solid is Inches 20.

What's the Solid Content? *Anſw.* Inches 1920.

The Area of the Baſe (by *Prob.* 24) is 96 Inches: and then it's,

As 1 ·· 96 :: 20 ·· 1920 Inches, Solid Content required.

Examp. 4. A Cube (which is a Quadriangle Priſm, of equal Length, Breadth and Depth, being cloathed with ſix equal Squares) whoſe Sides is Inches 12: What's the Solid Content? *Anſw.* Inches 1728.

For, As 1 ·· Square of 12 :: 12 ·· 1728: That is, the extent from 1 to 12, turned over two times from 12, reacheth to Inches 1728 the Solid Content required.

Examp. 5. Parallelepepidon, or a Quadrangle Priſm, whoſe Baſes are two equal Squares of each one.

$$\left.\begin{array}{l}\text{Side}\\ \text{Length}\end{array}\right\}\text{is Feet}\left\{\begin{array}{c}1.25\\ 21.75\end{array}\right\}\text{Parts of 100}$$

What's the Solid Content? *Anſw.* Feet 33.9 Tenths.

For; As 1 ·· Square of 1.25 :: 21 75 ·· Feet 33,9; that is, the Extent from 1 to 1.25, being turned two times from 21.75 will reach to Feet 33.9. the Solid Content required.

Examp. 6. A Parallelepepidon, or a Quadrangle Priſm, whoſe Baſes are two equal Long Squares, in each,

$$\left.\begin{array}{l}\text{The}\left\{\begin{array}{l}\text{Breadth is ——— 1.6}\\ \text{Depth is ——— 2.5}\end{array}\right.\\ \text{And Length of the Solid 15.5}\end{array}\right\}\text{Feet}$$

What's the Solid Content? *Anſw.* Feet 62.

For it is As 1 ·· 1.6 :: 2.5 ·· 4 Area of the Baſe

Then; as 1 ·· 4 :: 15.5 ·· 62 Feet, Solid Content required

In the like manner may the Solid Content of any Priſm be found, let its Baſe be of what Form ſoever; for its Area may be found by *Prob* 20, 21, 22, 23, 24, 25, 26 or 27, and the Solid Content of the Priſm, by the General Rule in the *Prob.* 31.

Prob. XXXII. *The Dimenſions of a Pyramid given; to find the Solid Content.*

Definition 1. A *Pyramid* is a *Strait Solid*, having one *Baſe*, and at t'other end a Punct, called the *Vertex.*

2. A *Pyramid*, takes its Sir-name from its *Baſe*; as a *Round*, an *Elliptic*, a *Triangular*, a *Quadrangular*, or a *Multangular-Pyramid*; all are meaſured by this one *General Rule.*

As 3 .. *Area of Baſe* : : *Length* .. *Solid Content.*

Note; By *Length* underſtand a *Perpendicular* from the *Vertex* to the *Baſe*; and not the Length of the *Pyramid* on its outſide from *Vertex* to *Baſe.*

Examp. A Round *Pyramid*, called by ſome a *Cone*, whoſe

$$\left.\begin{array}{l}\text{Diameter at } \textit{Baſe} \text{ —— } 21\\ \text{Perpendicular Length } 30\end{array}\right\} \textit{Inches}$$

What's the *Solid Content*? *Anſw.* 3465 Inches

For the *Area of the Baſe* is *Inches* $346\frac{5}{10}$ by *Prob.* 20:

And

Then; As 3 ·· 346.5 :: 30 ·· 3465 *Inches*, which is the *Solid Content* required.

The like do for any other *Pyramid*, which I paſs over, having given *Six Examples* in a *Priſm*, and leave you to apply them here.

Prob. XXXIII. *The Dimenſions of a Priſmoid given; to find its Solid Content.*

Definition 1. A *Priſmoid* is a *Strait Solid* having two unequal *Baſes* or *Ends*, but are parallel, like, and a-like ſituate.

2. A *Priſmoid*, is as various as a *Priſm*, and is no other than the *Fruſtum of a Pyramid.*

2. *Fruſtum of a Pyramid*, is the lower Part of it, when the upper Part is cut off Parallel to the *Baſe*; and all of them may be meaſured by this *General Rule.*

1. Multiply the *Area of, each Baſe* together, and from the Product extract the *Square Root.*

2. Add the *Area of each Baſe*, and that *Square Root* into one Sum; Then,

3. Say, As 3 · · *that Sum* : : *Length* ·· *Solid Content.*

But for a *Square Priſmoid*, take this *Particular Rule.*

1. To the *Square of each ſide*, add the *Product* of the *ſides* into one *Sum*: Then,

Say, As 3 ·· that *Sum* : : *Length* .. *Solid Content.*

And for a *Round Priſmoid*, this is the *Rule.*

1. Add the Square of each Diameter, and the Product of the Diameters into one Sum : And then,

2. Say, As 3.82 .. that Sum : : Length .. Solid Content.

Or more largely thus ; As 3.8197, is to the foreſaid Sum, ſo is the Length to the Solid Content.

Examp. 1. *A Square Priſmoid (or the Fruſtum of a Square Pyramid) whoſe*

$$\left.\begin{matrix}\text{Greateſt}\\\text{Leſſer}\end{matrix}\right\}\text{ Side is Inches }\left\{\begin{matrix}15\\9\end{matrix}\right.$$

Perpendicular Length 60 Inches

What's the Solid Content ? *Anſw.* 8820 Inches.

$$\text{For ; As } 1 \,..\, \left\{\begin{matrix}15\\9\\9\end{matrix}\right\} : : \left\{\begin{matrix}15\\9\\15\end{matrix}\right\} \,..\, \left\{\begin{matrix}225 \text{ Square}\\81 \text{ Square}\\135 \text{ Product}\end{matrix}\right.$$

Sum of the two Squares and Product is 441 Inches

Then, As 3 .. 441 : : 60 .. 8820, Solid Inches required.

Examp. 2. *A Round Priſmoid (or the Fruſtum of a Cone) whoſe*

$$\left.\begin{matrix}\text{Greateſt}\\\text{Leſſer}\end{matrix}\right\}\text{ Diameter is Feet }\left\{\begin{matrix}1.5\\0.9\end{matrix}\right\}\text{ Tenths}$$

Perpendicular Length —— 60. Feet.

What's the Solid Content ? *Anſw.* 69.25 parts of 100.

$$\text{For ; As } 1 \,..\, \left\{\begin{matrix}1.5\\0.9\\0.9\end{matrix}\right\} : : \left\{\begin{matrix}1.5\\0.9\\1.5\end{matrix}\right\} \,..\, \left\{\begin{matrix}2.25 \text{ Square}\\0.81 \text{ Square}\\1.35 \text{ Product}\end{matrix}\right.$$

Sum of the two Squares and Product —4.41 Inches

Then, As 3.82 .. 441 : : 60 .. 69.25, Solid Inches required.

Example 3. *An Elliptick Priſmoid, or the Fruſtum of an Elliptick Cone, whoſe*

Greateſt Diameter at Top, Inches 7.5 Tenths
Leaſt Diameter at Top ———— 5.
Greateſt Diameter at Bottom —— 8.7
Leaſt Diameter at Bottom ——— 5.8
Perpendicular Length ——— 47.0

What's the Solid Content? *Anſw.* 1617 Inches. For,

$$\text{As } 1 \,..\, \left\{\begin{array}{l}5.\\5.8\end{array}\right\} :: \left\{\begin{array}{l}7.5\\8.7\end{array}\right\} \,..\, \left\{\begin{array}{l}37\ 5 \text{ Area of Top Long ſquare}\\50.46 \text{ Area of Bottom.}\end{array}\right.$$

And,

As 1 .. 37.5 :: 50.46 .. 1892.25 whoſe SquareRoot is —— 43.5
Area at Top —— 37.5
Area at Bottom — 50.46

Sum is — 131.46

Then; As 3.82 .. 131.46 :: 47 .. 1617 Solid Content in Inches required.

If the Baſes of the foreſaid Priſmoid had been long ſquares the Work is the ſame, except only in the laſt Proportion; and having the ſame Dimenſions, its Solid Content is Inches 2060, very near: For it is thus;

As 3 .. 131.46 :: 47 .. 2059.5 Inches Solid Content.

Prob. XXXIV. *The Dimenſions of a Pyramidoid given; to find it's Solid Content.*

Definition 1. A *Pyramidoid* is not a ſtrait Solid, it hath one Baſe, and at t'other end a Punct call'd the Vertex; but the out-ſide from Baſe to Vertex, is convex, either Spheriodical, Parabolical, or Hyperbolical, *&c.*

2. A *Pyramidoid*, takes its Sir-name from its Baſe and out-ſide; as a Spheriodical, Parabolical, or Hyperbolical Round Pyramidoid; and ſo of the reſt, as in a Pyramid; all may be meaſured by this one General Rule.

As 1.5 .. Area of the Baſe :: Length .. Solid Content, when a Spheriodical Pyramidoid; but if

$$\left.\begin{array}{l}\text{Pyrabolical}\\\text{Hyperbolical}\end{array}\right\}\text{the firſt Term is }\left\{\begin{array}{l}2.\\2.4\end{array}\right.$$

Examp. A Round Pyramidoid, called by ſome a Conoid, whoſe

$$\left.\begin{array}{l}\text{Diameter at the Baſe —— } 21\\\text{Perpendicular Length— } 30\end{array}\right\}\text{ Inches}$$

$$\text{What's the Solid Content, if}\left\{\begin{array}{l}\textit{Spheriodical?}\\\textit{Parabolical?}\\\textit{Hyperbolical?}\end{array}\right\}\textit{Anſw.}\left\{\begin{array}{l}6930\\5197.5\\4331.2\end{array}\right.$$

The Area of the Baſe is Inches 146.5 Tenths, by *Prob.* 20. And then it's,

$$\text{As}\left\{\begin{array}{l}1.5\\2.\\2.4\end{array}\right\} \,..\, 146.5 :: 30 \,..\, \left\{\begin{array}{ll}6930 & \textit{Spheriodical}\\5197.5 & \textit{Parabolical}\\4331.2 & \textit{Hyperbolical}\end{array}\right\}\textit{Cont, in Inches}$$

More Examples I think here needleſs, having given ſo many in a Priſm, and the *Rule* for this and that being ſo like.

Prob. XXXV. *The Dimenſions of the Fruſtum of a Parabolical Pyramidoid given; to find the Solid Content.*

Difinition. *Fruſtum*, is the lower Part of a Pyramidoid, cut parallel to its Baſe.

A General Rule,

This is the ſame with the *General Rule* for a Priſmoid, ſave only in the third Precept, which in this Caſe is thus.

As 2 .. that Sum : : Length .. Solid Content required.

But for the Fruſtum of a Square Parabolical Pyramidoid, take this Particular Rule.

1. To the Square of the greateſt ſide, add the Square of the leaſt Side into one Sum : Then,

2. Say, As 2 .. that Sum : : Length .. Solid Content required

And for a *Round Fruſtum*, that is Parabolical, the Rule is;

1. Add the Square of each Diameter into one Sum ; Then

2. Say, As 2.546 .. that Sum : : Length .. Solid Content.

Or more largely thus; As 2.54649, is to the foreſaid Sum ; ſo is the Length to the Solid Content.

Examp. 1. The Fruſtum of a Square Parabolical Pyramidoid, whoſe

Side at Top ——————— Inches 4
Side at Bottom ——————— 6
Perpendicular Length ——————— 48
What the Solid Content? *Anſw.* 1824 Inches

For ; As 1 .. 4 : : 4 .. 16 the Square at Top
As 1 .. 6 : : 6 .. 36 the Square at Bottom
As 1 .. 4 : : 6 .. 24 the Product of the two Sides

Sum of the two Squares 76 Inches, and the Product of the two Sides.

Then ſay ; As 2 .. 76 : : 48 .. 1824 Inches, the Solid Content

Examp. 2. The Fruſtum of a Round Parabolic Pyramidoid, (or the Fruſtum of a parabolic Conoid) whoſe

Diameter at Top ——————— 4 }
Diameter at Bottom ——————— 6 } Inches
Perpendicular Length ——————— 48 }
What's its Solid Content? *Anſw.* 1433 Inches.

For; As 1 ·· 4 :: 4 ·· 16 the Square at Top.
As 1 ·· 6 :: 6 ·· 36 the Square at Bottom.
As 1 ·· 4 :: 6 ·· 24 the Product of both Diameters.

Sum of the two Squares 76 Inches, the Product of both Diam.
Then ſay; As 2.546 ·· 76 :: 48 ·· 1433 Inches, the Solid Cont.

Sect V. *The Application of the whole, in meaſuring Board, Glaſs, Plaiſtering, Painting, Paving, and Land; Timber and Stone; Gauging of Cask, and a Ships Hold.*

1. Board or Plank, Glaſs, and flat Stone, are meaſured by the *Foot Square*, or *Superficial Feet*, containing 144 Square Inches, or 12 times 12: So that to know how many Square Feet are contained in the Area, or Content of any Superficies taken in Inches, the Proportion is this;

As 144 ·· 1 :: Content in Inches ·· Content in Feet.

But the eaſieſt way, is to have the Foot of 12 Inches divided Decimally into 100 Parts, called Foot Meaſure; and by ſuch a Foot to take the Dimenſions of the thing you would meaſure, or know the Content of in Feet.

Then conſider, if the thing to be meaſured be a Circle, Triangle, Square, Long-ſquare, &c. the Rules proper for ſuch a Figure (in *Sect.* 3. of this *Chapter*) direct to find the Area. That is,

If the thing to be meaſured be a Circle, then *Prob.* 20 or 21 ſheweth how to find its Area; if its a Triangle, then *Prob.* 24 gives a Rule to find the Area; if a Parallelogram, *Prob.* 25 hath a Rule to find its Area, whether it be a Square, a Long-ſquare, a Rhombus, or Rhomboids; now Floars and Ceilings of Houſes are generally Squares, or Long-Squares; alſo Boards, Planks and Flat Stones, (are commonly) Squares or Long-ſquares: If a Trapezia, then *Prob.* 26 ſheweth how to meaſure it; if it be an Ellipſis, *Prob* 27 hath a Rule for its meaſuring; and ſuch are Oval Tables. And if the thing to be meaſured be a Parobola, then *Prob.* 28 ſheweth how to find its Area.

2. *Plaiſtering*, *Painting*, and *Paving*, is meaſured by the Yard-Square, containing Nine Square Feet; and therefore after you have found the Content in Feet; the Proportion is this;

As 9 ·· 1 :: Content in Feet; the Content in Yards.

3. *Timber* is meaſured by the Cubic Foot, containing 1728

Solid Inches: And when the Content of any Solid Body is known in Cubic Inches, to reduce them into Cubic Feet, which is the Timber, or Stone Foot, the Proportion is this:

As 1728 .. 1 : : Cubical Inches .. Solid Feet.

But meaſuring the Dimenſions of a Solid, by the aforeſaid Decimal Feet, the Rules proper for it (in *Sect.* 3. of this *Chap*) as a Sphere, Priſm, *&c.* Finds the Solid Content in Feet.

That is, if it be a Sphere, then *Prob.* 29 hath a Rule to find its Solid Content, ſuch are Bullets, and Granadoes uſed in great Guns, Mortars, or Bombs.

If a Spheriod, then *Prob.* 30 ſheweth the meaſuring of it, and ſuch are things in Shape like an Egg, whoſe Ends are equal.

If a *Priſm*, then *Prob.* 31 directs its Meaſurement, and by it, all ſtrait pieces of Timber or Stone, whoſe Ends are alike and equal, are meaſured.

If a *Pyramid*, then *Prob.* 32 ſhews the Meaſuring it, and ſuch are Spire-Steeples, and all Strait Solids ending in a Point at one End.

If a *Priſmoid*, then *Prob.* 33 directs its Meaſuring, and ſuch is all Taper Timber, whether Round, or Square.

If a *Pyramidoid*, then *Prob.* 34 ſheweth the Meaſuring of it, and ſuch is the half of all Casks, if they were continued from the Bung by the Head, till they End in a Point.

If a *Fruſtum* of a *Parobolical Pyramidoid*, then *Prob.* 35 ſerves to meaſure it, and ſuch are *Cloſe Casks*, if cut in halves through the Bung, and Parallel to each Head; ſo that by this *Problem* is taught the way of finding the half Content of a Cask, whoſe double is the whole Solid Content: But a more particular Rule for Gauging a Cask, followeth in the next Problem.

4. Land is meaſured by the Rod or Pole, containing in Length, Feet 16½, and a Square Rod is Feet 272¼; an Acre of Land containeth 160 Square Rods.

Now the readieſt way to caſt up the Content of Land in Acres is to take the Dimenſions by a *Four Pole Chain*, Decimally divided (that is into an 100 Links) then the Rules (in *Sect.* 3. of this *Chap.*) proper to the Form of it, (whether a Triangle, Square, Long Square, Rhombus, Rhomboides, or Trapezia) finds the Content in the Square Chains; which are turned into Acres thus;

As 10 .. 1 : : Square Chains .. Acres.

5 *Gauging* is by the Gallon, and that either *Beer* containing 282 *Cubical Inches*, or *Wine* 231: Then to reduce *Cubical Inches* into Gallons of either Kind the Rule is;

As $\left\{\begin{matrix}282\\231\end{matrix}\right\}$ ·· 1 :: *Cubical Inches* ·· *Gallons* of $\left\{\begin{matrix}\textit{Beer}\\\textit{Wine}\end{matrix}\right.$

So that the Dimenſions of any *Solid Body* taken in Inches, the proper Rules for that Body, finds its Content in Inches, and the Rule above finds the Gallons of *Beer* or *Wine* it will hold.

Prob. XXXVI. 6. *To Gauge a Cask, taken, as the middle Fruſtum of a Spheriod.*

The Rule. Add twice the Square of the Bung-Diameter, and once the Square of the Head, into one Sum: Then ſay,

2. As 3.82 ·· that *Sum* :: *Length* ·· *Solid Content* of the Cask in Inches; and then the Gallons of Beer or Wine are found by the Foregoing Rule. Or thus,

1. Say, As 1 ·· 0.7 :: *Difference of Head and Bung* ·· a *Fourth Number.*

2. That 4th Number add to the Head Diameter, the Sum is a Mean Diameter: Then ſay,

As $\left\{\begin{matrix}18.95\\17\,15\end{matrix}\right\}$ ·· *Sq. Mean. Diam.* :: *Length* ·· $\left\{\begin{matrix}\textit{Beer}\\\textit{Wine}\end{matrix}\right\}$ *Gallons*

Exam. A Cask whoſe Bung Diameter is Inches 23
Head Diameter ——— ——— *Inches* 19 9
Length of the Cask ——— —— *Inches* 27 4

What's its *Content* in *Beer*, or *Wine Gallons*? *Anſw. Beer Gallons* 36.99, *or Wine Gallons* 45.5.

As 1 ·· 0.7 :: 3.1 ·· 217, which added to 19.9; makes the Mean Diameter to be 22.07. Then,

As $\left\{\begin{matrix}18\,95\\17.15\end{matrix}\right\}$ ·· *Square* 22 07 :: 27.4 ·· $\left\{\begin{matrix}36.99\ \textit{Beer}\\45.5\ \textit{Wine}\end{matrix}\right\}$ *Gallons*

That is; the Extent from the Firſt Term to the Second, twice turned over from the Third, gives the Gallons requird.

Prob. XXXVII. 7. *To meaſure a Ship; that is, to find her Tunnage.*

The Rule. 1. Say as 1 ·· *Breadth* :: *Half Breadth* ·· *Fourth Number*

2. Then ; As 94 .. 4th *Number* : : *Length* .. *Tuns* required.

Examp. A Ship 75 Feet by the Keel, and 23 Feet by the Beam : What's her Tunnage ? *Anſw.* 211 Tuns.

For, As 1 .. 23 : : 11.5 .. 264.5, the 4th Number.

Then, As 94 .. 264.5 : : 75 .. 211 Tuns required.

8. *To meaſure Bales or Caſes, or to give the Tunnage of them ; they are Priſms, and their Dimenſions taken by the Decimal Foot ; the Content in Cubical Feet is found by Prob.* 31. And then ſay,

As 66 .. 1 : : Cubical Feet .. Tuns required.

Or thus, As 66 .. *Area Baſe* : : *Length* .. Tuns required.

Examp. A *Bale* whoſe Breadth is —— Feet 4.2
Depth —— 2.6
Length —— 5.7

What's the *Content* in Tuns ? *Anſw.* 0.943 Parts. For,

As 1 .. 4.2 : : 2.6 .. 10.92 *Area of its Baſe* : Then

As 66 .. 10.92 : : 5.7 *Tuns*, 0 943 Parts required.

Note, That 66 Feet is the Content of a Caſe that incloſeth two *Engliſh Butts*, ſo that this *Rule* excludes the *Cantlings* of the *Cask*, which is better than $\frac{1}{3}$ part ; therefore allowing for the *Cantlings* or *Vacancy* to be 26 Feet, the remaining 40 Feet is to be counted for a Tun : And then,

The Rule is, As 40 .. *Area Baſe* : : Length .. Tuns required.

And then the foreſaid *Bale* contains *Tun* 1.556 parts. For,

As 40 .. *Area Baſe* 10.92 : : *Length* 5.7 .. *Tun* 1.556 parts.

So much for *Geometry* ; *Trigonometry* is next in order to be learned.

Chap. II. *Containing the Doctrine of Plain Triangles.*

Trigonometry, is that part of *Geometry* which treats more particularly about the meaſuring of Triangles, wherein having three things given ; either Sides, Angles, or both ; a 4th (Side or Angle may be found ; and is either *Plain* or *Spherical* ; It's the former we begin with.

Section I. *Of Things neceſſary to be underſtood, relating to Plain Trigonometry.*

1. A *Triangle*, is any *Three-corner'd* Figure; it conſiſteth of ſix things, *Three Sides* and *Three Angles*, and is either *Plain* or *Spherical*

2. A *Plain Triangle* is projected on a Plain Superficies, and therefore its *Sides* are *Right-lines*: But the *Sides* of a *Spheric Triangle*, are *Arks of the Sphere*, of which more in the Chapter of *Spheric Trigonometry*.

3. An *Angle* is the meeting of any *two Lines*, making a *Corner*; and is either a *Right-angle*, containing juſt 90 deg. or *Oblique* more than 90 deg. called an *Obtuſe-angle*; or leſs than 90 deg. called an *Acute-angle*.

4. When two *Lines* croſſing one another, make the Angles on every ſide equal, then thoſe *Angles* are *Right*, and the *Lines* are *Perpendicular*.

5. A *Degree*, is the 360th part of the *Periphery* of any *Circle*; the 4th Part 90 is called a Quadrant, and the half 180 is a *Semicircle*: Alſo a *Degree* containeth 60 *Min.* and a *Min.* 60 *Seconds*, &c. as in *Prob. 9. Defin. of Geometry*, in *page* 15.

6. By *Complement of any Degrees*, underſtand what thoſe *Degrees* want of 90.

7. A *Triangle*, is either *Right-Angled*, having one *Right-Angle*; or *Oblique*, having no *Right-Angle*.

8. In a *Right-angle Triangle*, the *Side* oppoſite to the *Right-angle*, is called the *Hypotenuſe*, and the two *Sides* containing the *Right-angle*, are called *Legs*.

9. In all *Plain Triangles*, the Sum of the three *Angles* added together are equal to 180 *Degrees*.

10. The *Angles* (of a Plain Triangle) being only given, the *Proportion* of the *Sides* can only be determined; Therefore,

11. In a *Right-angle Triangle*, two things given (if one be a *Side*) are ſufficient to find a *Third*: But,

12. In *Oblique Triangles* three things and one of them a *Side*, muſt be given to find a Fourth.

13. *Three Letters ſignifies an Angle*; as BAC ſignifies the *Angle* A: And *Two Letters a Side*; as AB ſignifies the *Side* AB, *&c.*

14. *Given Things*, whether *Sides* or *Angles*, are marked with a *Daſh*, thus, (′) and *required things*, with a *Cypher* thus, (°),

15. $\left\{\begin{array}{l}\text{d.}\\ \text{m.}\end{array}\right\}$ after any *Number* ſignifies $\left\{\begin{array}{l}\textit{Degrees,}\\ \textit{Minutes,}\end{array}\right\}$ thus.

25d. is 25 *Degrees*, and 31m. is 31 *Minutes*.

S.	ſtands for	Sine
S. c.		Sine Complement, or Co-Sine.
T.		Tangent.
T. c.		Tangent Complem. or Co-Tang.
Sec.		Secant.
Sec. c.		Secant Complement or Co-Secant.
Co. Ar.		Complement Arithmetical.
..		is to, or to the
: :		ſo is ; As thus, 2 .. 4 : : 3 .. *6*.

That is, As 2 is to 4, ſo is 3 to 6.

16. There are Seven Caſes in *Right-angle Triangles*, and Six in *Oblique*. Their Solution follows ; but firſt of *Right-angle Triangles*.

Sect. II. *The firſt Axiom, and the ſeven Caſes of Plain-Right angle-Triangles depending thereon.*

Axiom 1. IN all *Plain-Right-angle Triangles*, if one of its Sides be made Radius, the other two will be either Sines, Tangents, or Secants ; That is,

1. If the Hypotenuſe be Radius, each Leg is the Sine of its oppoſite Angle. See *Plate* 2. *Fig.* 1. for the firſt *Axiom*.

2. If one Leg be Radius, the Hypotenuſe is Secant, and the other Leg is Tangent of the Angle oppoſite to this Leg. See *Plate* 2. *Fig.* 2. for the firſt *Axiom*.

And what Proportion the Side made Radius, hath to Radius ; the ſame hath the other Sides, to the Sines, Tangents, or Secants by them repreſented ; and the contrary. And,

Note 1. To find a Side, any Side may be Radius, ſaying thus ;

As the Word on the Side given ; is to the Side given ;
So is the Word on the Side required, to the Side required.

Note 2. To find an Angle, one of the given Sides muſt be Radius. Then ſay,

As one given Side, is to the Word on it ;
So is the other given Side, to the Word on it.

* Obſerve to begin with the Side made Radius.

Theſe two Notes (to the diligent *Reader*) are ſufficient to frame any Proportion by the firſt *Axiom*, making any Side of a *Right-angle Triangle* the Radius.

Problem I. Caſe 1. *The Angles and Hypotenuſe given; to find either of the Legs.*

Examp. In the Right Angle Triangle ABC *Plate* 2. *Fig.* 1.

The { *Hypot.* AC 121 Leag. / *Angle B A C* 54d. 30m } given: Leg { AB / BC } required

This Triangle is made by *Prob* 10. of *Geometry.*

If you make *A C* Radius, the Proportion (by *Axiom* 1. and *Note* 1.) is thus,

As Radius, is to the Hypotenuſe *A C*; ſo is the Sine of the Angle *B AC*, to the Leg BC. Or thus briefly.

Radius .. Hypot. A *C* : : S. *B A C* .. Leg *B C.*
121 Leag. 54d. 30m.

9.910686
2.082785

--- Leag.

~~1~~1 993471|98.51 parts.

To work Proportions by Logarithms, obſerve this, *General Rule.* Add the Logarithm of the Second and Third Term together; and from that Sum ſubtract the Logarithm of the firſt Term, the Remainder is the Logarithm of the fourth Term, or Number ſought.

As in the foregoing Proportion, the Sum of the Logarithms of the Second and Third Terms added together is *11.993471*; from which it is eaſy to ſubtract the Logarithm of the Firſt Term (being Radius) by cancelling, cutting off, or leaving out the firſt Figure to the Left-hand, and then it is *~~1~~1.993471*, which brings forth *98.51*; that is, Leagues 98 51 Parts of 100 for the Leg BC, the Fourth Term or Side required.

By Gunter's Scale *thus.*

Radius .. A C : : S. B A C .. B C. That is,
S. 90d. .. 121 Leag. : : S. 54d. 30m. .. Leag. 98.5 Tenths.

That is to ſay, the Extent from Sine 90d. (on the *Line* of *Sines*) to 121 Leagues, or Miles (on the *Line of Numbers*) will reach from Sine 54d. 30m. (on the ſame *Sines*) to Leagues or Miles 98.5 Tenths, (on the Line of *Numbers*) for the Leg BC near as above.

Obſerve the like in all that follows, except in thoſe Proportions wherein is the Word *Secant*, which is wrought only by the Logarithms.

The three ſeveral Proportions making each Side Radius, to find the Leg BC, are theſe which follow.

$$\left.\begin{array}{l}\textit{Radius} \;..\; \text{S. BAC} \\ \text{Sec. BAC} \;..\; \text{T. BAC} \\ \text{Sec. ACB} \;..\; \textit{Radius}\end{array}\right\} : : \textit{Hypotenuſe}\ \text{AC} \;..\; \textit{Leg}\ \text{BC.}$$

Likewiſe to find the *Leg* AB, they are theſe following.

$$\left.\begin{array}{l}\textit{Radius} \;..\; \text{S. ACB} \\ \text{Sec. BAC} \;..\; \textit{Radius} \\ \text{Sec. ACB} \;..\; \text{T. ACB}\end{array}\right\} : : \textit{Hypotenuſe}\ \text{AC} \;..\; \textit{Leg}\ \text{AB.}$$

Note; When *Radius is not the firſt Term* in the *Proportion*, then take the *Complement-Arithmetical* of the *Logarithm* of the *Firſt Term*; (which how to find is ſhew'd in *Chap.* 1. *Propoſition* 9. *of the Uſe of the Table of Logarithms, Sines, Tangents and Secants,* in *Page* 300.) This *Comp. Arith.* or Co. Ar. add to the *Logar.* of the *Second* and *Third Terms*, and from the *Characteriſtic* of their Sum ſubtract 10 or 20, the remaining Figures is the *Logarithm* of the *Fourth Term* ſought; as may be ſeen in the following *Proportion* in *Problem* II.

Prob. II. Caſe 2 and 3. *The Angles and one Leg given; to find the Hypotenuſe, and the other Leg.*

Examp. In the Right-Angle Triangle ABC *Plate* 2: *Fig.* 2.

$$\text{The}\left\{\begin{array}{l}\textit{Ang.}\ \text{ACB 35d. 30m.} \\ \textit{Leg}\ \text{BC 98 Leagues}\end{array}\right\}\text{given}:\left\{\begin{array}{l}\textit{Hyp.}\text{AC} \\ \textit{Leg}\ \text{AB}\end{array}\right\}\text{required}$$

This *Triangle* is made by *Problem* 12. of *Geometry*.

Make the *Hypotenuſe* AC *Radius*, and the Proportion (by *Axiom* 1 and *Note* 1.) is thus;

As the *Sine* of the *Angle* BAC, is to the *Leg* BC; ſo is *Radius* to the *Hypotenuſe* AC. Or thus,

S. BAC .. Leg. BC : : *Radius* .. Hypotenuſe AC.

54d. 30m. 98 Leg.

$$\begin{array}{rl} & 10.000000 \\ & 1.991226 \\ \text{Co. Ar:} & 0.089314 \\ \hline & \cancel{1}2.080540 \end{array}\left(\begin{array}{l}\textit{Leag} \\ 120\,\frac{4}{10}\end{array}\right.$$

By Gunter's Scale thus;

S. BAC .. Leg BC : : *Radius* .. *Hypotenuſe A C* That is,

S 54d. 30m .. 98 *Leag.* : : S 90d. .. *Leag.* 120.4 *Tenths*.

That is, The Extent from *Sine* of 54d. 30m. (on the *Line of Sines*) to 98 *Leagues* (on the *Line of Numbers*) will reach from *Sine* 90d. to *Leag*, 120.4 *Tenths*, the *Hypotenuſe* required.

The Three ſeveral Proportions, making each ſide Radius, to find the Hypotenuſe, are theſe following.

$$\left.\begin{array}{l}\text{S. BAC .. Radius}\\ \text{T. BAC .. Sec. BAC}\\ \text{Radius .. Sec. ACB}\end{array}\right\} :: \text{Leg BC .. Hypotenuſe AC.}$$

And to find the Leg AB, they are theſe;

$$\left.\begin{array}{l}\text{S. BAC .. S. ACB}\\ \text{T. BAC .. Radius}\\ \text{Radius .. T. ACB}\end{array}\right\} :: \text{Leg BC .. Leg AB.}$$

Note; In working by *Gunter*, when a Tangent is mentioned, the Radius then is the Tangent of 45d. as in the two laſt Proportions it is,

As T. B A C .. *Radius* : : *Leg* B C .. *Leg* A B. Which is
T. 54d. 30m. .. T. 45d. : : 98 *Leag.* .. *Leag.* 69.8 Tenths.

That is, the Extent from 54d. 30m. to 45d. (on the *Line of Tangents*) will reach from 98 Leagues, to Leagues 69.8 Tenths on the *Line of Numbers*, for the Leg AB.

As Radius .. T. A C B : : *Leg* BC .. *Leg* AB. Which is
T. 45d. .. T. 35d. 30m. : : 98 *Leag.* .. *Leag.* 69.8 Tenths,

That is, the Extent from T. 45d. to T. 35d 30m. will reach from 98 Leagues, to Leag. 69.8 Tenths as before.

Prob. III. Caſe 4 and 5. *The Hypotenuſe and one Leg given; to find the Angles and the other Leg.*

Examp. In the Right Angle Triangle ABC. *Plate* 2. *Fig.* 3.

$$\text{The}\left\{\begin{array}{l}\text{Hyp. AC 121}\\ \text{Leg AB 69}\end{array}\right\}\textit{Leagues}\text{ given:}\left\{\begin{array}{l}\text{ACB or BAC}\\ \text{and Leg BC}\end{array}\right\}\text{req.}$$

This Triangle is made by *Prob.* 11. of *Geometry.*

1. To find the Angles,

If you make the Hypotenuſe A C Radius, the Proportion (by *Axiom* 1. and *Note* 2.) is thus;

As the Hypotenuſe AC, is to Radius; ſo is the Leg AB, to the Sine of the Angle ACB. Or thus;

Hypot. AC .. *Radius* : : *Leg* AB .. S. ACB.
121 *Leag.* .. S. 90d. : : 69 *Leag.* .. S. 34d. 45m. Which
ſubtract from ———————— 90d. 00m.
Remainder is Angle BAC —— 55d. 15m by the 9th of *Section* 1. of this *Chapter* in Page 35.

And if the Leg AB is Radius, then the Proportion (by *Axiom* 1. and *Note* 2.) is thus.

As the Leg AB, is to the Radius ; ſo is the Hypotenuſe AC to the Secant of the Angle BAC. Or thus,

AB 69 Leag. .. Radius : : AC 121 Leag. .. Sec BAC 55d 15m.

Note; This Proportion is not wrought on the *Gunter* becauſe of the Word *Secant* in the 4th Term ; but being wrought by the *Tables* (as before directed) will produce the Angle BAC 55d. 15m. as above ; which ſubtracted from 90d. gives 34d. 45m. for the Angle ACB as before.

2. The Leg BC may be found by the 1ſt or 2d Caſe ſeveral Ways : As thus,

$$\left.\begin{array}{lll} \text{Radius} & ..\ AC :: & S.\ BC \\ S.\ ACB & ..\ AB :: & S.\ BAC \\ \text{Sec } BAC & ..\ AC :: & T.\ BAC \\ \text{Radius} & ..\ AB :: & T.\ BAC \\ \text{Sec } ACB & ..\ AC :: & \text{Radius} \\ T.\ ACB & ..\ AB :: & \text{Radius} \end{array}\right\} ..\ BC \text{ Leagues } 99.4 \text{ Tenths}$$

Prob. IV. Caſe 6 and 7. *The Legs given ; to find the Angles and Hypotenuſe.*

Examp. In the Right-angle Triangle ABC. *Plate* 2. *Fig* 4.

$$\text{The Leg}\left\{\begin{array}{l} AB\ 98 \\ BC\ 69 \end{array}\right\}\text{Leag. given:}\left\{\begin{array}{l} \text{Angle } BAC \text{ or } ACB \\ \&\ \text{Hypotenuſe } AC \end{array}\right\}\text{req.}$$

This Triangle is made by *Prob.* 13. of *Geometry*.

1. Make the Leg AB Radius, and the Proportion (by *Axiom* 1. and *Note* 2.) is thus ;

As the Leg AB, is to Radius ; ſo is the Leg BC, to the Tangent of the Angle BAC. Or thus,

Leg AB .. Leg BC : : Radius .. T. BAC,
98 Leag. .. 69 Leag. : : T. 45d. .. T. 35d. 09m. which
Subtract from ———————— 90d. 00m.

The Remainder is ———————— 54d. 51m. for the Angle ACB, by the 9th of *Section* 1. of this *Chapter*, in *Page* 35.

And if the Leg BC is made Radius, the Proportion is thus;

Leg BC .. Leg AB : : Radius .. T. ACB.
69 Leag. .. 98 Leag : : T. 45d. .. T. 54d. 51m. as before ;

Which being ſubtracted from 90, leaveth 35d. 09m. for the Angle BAC. Either of theſe Proportions is ſufficient to find both Angles.

2. The Hypotenuſe AC may be found by the 2d Caſe ſeveral Ways.

Firſt, Making the Hypotenuſe AC Radius; thus,

$$\left.\begin{array}{l}\text{S. BAC .. BC}\\ \text{S. ACB .. AB}\end{array}\right\} :: \text{Radius .. Hypotenuſe AC.}$$

Secondly, making the Leg AB Radius; thus,

$$\left.\begin{array}{l}\text{Radius .. AB}\\ \text{T. BAC .. BC}\end{array}\right\} \text{Sec. BAC} :: \text{Hypotenuſe AC}$$

Thirdly, making the Leg BC Radius; thus,

$$\left.\begin{array}{l}\text{Radius .. BC}\\ \text{T. ACB .. AB}\end{array}\right\} :: \text{Sec. ACB .. Hypotenuſe AC.}$$

Theſe 6 Proportions, if the Learner works them, he'll find them all to produce Leagues 119.8 for the Hypotenuſe AC

Note; The 5th and 7th Caſes may be performed by the 47th Propoſition of the *Firſt Book of Euclid's Elements*, which proves the Square of the Hypotenuſe, is equal to the Sum of the Squares of the two Legs; Therefore,

1. By Natural Arithmetick, Extracting the Square Root; the Rules are theſe,

Firſt, In the 5th Caſe to find a Leg; when the Hypotenuſe, and one Leg is given. Thus,

The Square Root of the Difference of the Squares of the Hypotenuſe and one Leg, is the other Leg.

Secondly, In the 7th Caſe to find the Hypotenuſe, when both the Legs are given; thus,

The Square Root of the Sum of the Squares of both Legs, is the Hypotenuſe.

2. By Logarithms in theſe two Rules following.

Firſt Rule. When the Hypotenuſe and one Leg is given, to find the other Leg, thus,

Half the Sum of the Logarithms, of the Sum and Difference of the Hypotenuſe, and given Leg; is the Logarithm of the Leg required.

Second Rule. When both Legs are given, to find the Hypotenuſe, it is thus;

From the double Logarithm of the greater Leg, ſubtract the Logarithm of the leſſer Leg; the abſolute Number anſwering to it, add to the leſſer Leg; half the Sum of the Logarithms of that Sum, and leſſer Leg, is the Logarithm of the Hypotenuſe required.

Examp. 1. The *Hypotenuſe* AC 121 Leagues, and the Leg AB 69 Leagues: What is the Leg BC by the *Square Root*?

Hypotenuſe AC ——— 121 And *Leg* AB ——— 69
121 69
121 621
242 414
121 *Square* of AB is 4761

Square of AC is ——— 14641
Square of AB is ——— 4761

Diff. of the Square is ——— 9880(99.39 is the *Leg* BC
81
189)1780
1701
1983)7900
5949
19869)195100
178821

Remainder is ——— 16279

So that the *Leg* BC is Leagues 99.39 Parts of 100.

By Logarithms thus,

The *Hypotenuſe* AC ——— 121 Leagues
The given *Leg* AB ——— 69 Leagues

Sum of AC and AB ——— 190 its *Logarithm* is 2.278754
Difference of AC and AB ——— 52 its *Logarithm* is 1.716003
The Sum of the *Logarithm* is ——— 3.994757
The half Sum of theſe *Logarithms* ——— 1.997378

Whoſe abſolute Number is 99.39; that is, *Leagues* 99,39 Parts of 100 is the Leg BC, the ſame as before.

Examp. 2. The *Leg* AB is 98 Miles, and the *Leg* BC 69 Miles given: What is the *Hypotenuſe* AC? By the *Square Root.*

The

The *Leg* AB ———— 98.	And *Leg* BC ———— 69
98	69
784	621
882	414
Square of AB is ——— 9604	Square of BC is ——— 4761

Square of BC is ——— 4761

Sum of the *Square* is 14365(119.8 that is 119 Leagues $\frac{8}{10}$

1 is the Hypotenuſe AC.

21(43

21

229(2265

2061

2388(20400

19104

Remainder is ——— 1296

By Logarithms, thus,

The greater Leg AB 98, its *Logarithm* is ——— 1.991226

Multiply its *Logarithm* by ——— 2

The Double *Logarithm* of the *Leg* AB is ——— 3.982452

The leſſer *Leg* BC 69 *Miles*, its *Logarithm* is ——— 1.838849

Abſolute Number 139.2 anſwering the *Logar.* ——— 2.143603

Sum is ——— 208.2 its *Logarithm* is ——— 2.318481

The leſſer *Leg* BC 69 *Miles*, its *Logarithm* is ——— 1.838849

The Sum of the two laſt *Logarithms* is ——— 4.157330

The half is the *Logarithm* of AC 119,$\frac{8}{10}$ required 2.078665

Section III. *Three other Axioms, with the Six Caſes of Oblique Plain Triangles thereunto belonging.*

Axiom 2. IN all *Plain Triangles*, the *Sides* are in ſuch *Proportion* one to another, as are the *Sines* of their oppoſite *Angles*. That is,

1. As the *Sine* of any one *Angle*, is to its oppoſite *Side*; ſo is the *Sine* of any other *Angle*, to its oppoſite *Side*.

2. As a *Side*, is to the *Sine* of its oppoſite *Angle*: ſo is a *Side*, to the *Sine* of its oppoſite *Angle*.

Note; To find a *Side*, begin with an *Angle*; but to find an *Angle*, begin with a *Side*.

From this *Axiom* are drawn the Proportions for the Firſt, Second, and Third *Caſes* following.

Prob. V. Caſe 1. *Of Obliquangles Two Angles and one Side given; to find either of the other ſides.*

Examp. In the Oblique Triangle BDC. *Plate* 2. *Fig.* 5.

$$\text{The}\left\{\begin{array}{l}\text{Angle}\left\{\begin{array}{l}\text{BDC 101d. 25m}\\ \text{CBD 44d. 42m.}\end{array}\right.\\ \text{Side — BC 76 Yards}\end{array}\right\}\text{given: Side}\left\{\begin{array}{c}\text{CD}\\ \text{and}\\ \text{BD}\end{array}\right\}\text{req.}$$

This Triangle is made by *Prob.* 14. of *Geometry*.

1. The Proportion according to the *Second Axiom* for finding CD, is this;

As the Sine of the Angle *BDC*, is to the Side *BC*; ſo is the Sine of the Angle *CBD*, to the required Side *CD*. Or thus;

S. *B D C* .. Side *B C* : : S. *C B D* .. Side *C D* required.
S, 101d. 25m. .. 76 Yards : : S. 44d, 42m .. Yds. 54.5 Tenths
S. 180d 00m.

S. 78d. 35m.

Note; The Sine of 101d. 25m is found by ſubtracting it from 180d. according to Chapter 1. *Propoſition* 8. *Of the Uſes of the Tables of Logarithms*, &c. in *Page* 300.

2. To find the Side *B D*, the Proportion is,

S. B *D C* .. Side *B C* : : S. *B C D* .. Side B D.
S. 101d. 25m. .. 76 Yards : : S. 33d. 53m. .. Yds. 43.3 Tenths
180d. 00m.

S. 78d. 35m.

Prob. VI. Caſe 2 and 3, *Of Obliquangles.*
Two Sides, and one Angle oppoſite to one of them given; to find the other oppoſite Angle, and the Third Side.

Note; The given Angle Obtuſe, the Angle ſought is Acute. But when the given Angle is Acute, and oppoſite to the leſſer given Side, then the required Angle is doubtful; whether Acute or Obtuſe, and ought to be determined before the Operation.

Example, In the Oblique Triangle *B C D*. *Plate* 2. *Fig.* 6.

Side { BC 106 / BD 65 } Yards, Angle BCD 31d 49m. } given: { Angle *BDC Obtuſe*, and the Side CD } req.

This Triangle is made by *Prob.* 15. of *Geometry.*

1. For the Angle *B D C* the Proportion is,

As the Side *BD*, is to the Sine of the Angle *BCD*: ſo is the Side *BC*, to the Sine of the required Angle *BDC.* Or thus,

Side *B D* .. S. *B C D* :: Side *B C* .. S. BDC.
65 Yards .. S. 31d. 49m. :: 106 Yards .. S. 59d. 17m. which
Subtract from ——————— 180d. 00m.
Remainder is the Angle *BDC*— 120d. 43m.

Note; The Proportion produceth 59d. 17m. for the required Angle: But being it's Obtuſe, you muſt take it's Supplement to 180d. *viz.* 120d. 43m. as above.

2. Find the Third Angle by the 9th of *Section* 1. of this *Chapter*, in *Page* 35. then you may find *CD* by the *Firſt Caſe.*

This *Caſe* hath been omitted by moſt, the Reaſon (I ſuppoſe) is the doubtfulneſs of the required Angle; but if determined (before) to be either Acute or Obtuſe, the Third Side is limitted, and then may be a *Caſe* as well as any other. And the Proportion may be

S. B C D .. Side BD :: S. C B D .. Side CD.
S. 31d. 49m. .. 65 Yards :: S. 27d. 28m. .. Yds. 56.8 Tenths.
Or,
S. BDC .. Side BC :: S. C B D .. Side CD.
S. 120d. 43m. .. 106 Yds. :: S. 27d. 28m. .. Yds 56.8 Tenths. as before.

Axiom 3. IN all *Plain Triangles*; As the Sum of Two Sides, is to their Difference; ſo is the Tangent of the Half-Sum of their two oppoſite Angles, to the Tangent of the half Difference of the two unknown Angles.

Add the half Difference of the Angles to their half Sum, finds the greateſt Angle; and ſubtract the half Difference from the half Sum, finds the leſſer Angle.

Prob. VII. Caſe 4 and 5. *Two Sides, and their contained Angle given; to find either of the other Angles, and the third Side.*

Examp. In the Oblique Triangle BCD. *Plate* 2. *Fig.* 7.

Side { BC 109 / BD 76 } Leag, Angle CBD 101d. 30m. } given: { Angle { BDC or BCD } and Side CD } required.

This Triangle is made by *Prob.* 16, of *Geometry.*

1. For the Angles BCD, and BDC, the Operation is

Side	BC 109	The three Angles —— ——	180d. 00m.
	BD 76	Subtract the given Angle CBD	101d. 30m.
Sum of *Sides*	185	The 2 oppoſite *Angles* Sum is	78d. 30m.
Their *Differ.*	33	½Sum is	39d. 15m

Then, As the *Sum* of the *Sides* BC and BD, is to their *Difference*; ſo is the *Tangent* of half the *Sum of the Angles* BCD and BDC, to the *Tangent* of half their *Difference*. Or thus,

Sum BC&BD .. *Diff.* BC&BD : : T. ½ *Sum Angles* .. T. ½ Diff.
185 *Leagues* .. 33 *Leagues* : : T. 39d. 15m. .. T. 8d. 17m.
The half Diff. of the Angles —— 8d. 17m.

Added is the greater Angle —— 47d. 32m. BDC
Subtracted is the leſſer Angle —— 30d. 58m. BCD } req

2. The Proportion for the Side CD (by the *Firſt Caſe* of *Oblique Triangles*) may be this:

S. BCD .. Side BD : : S. CBD .. Side CD.
S. 30d. 58m. .. 76 Leag. : : S. 101d. 30m. .. Leag. 144.5 tenths

Axiom. 4. From the *Half Sum of the three Sides*, ſubtract each *Side* (but firſt that *Side* oppoſite to the *Angle required*, then the reſt) ſeverally, noting their *Remainders*. Then,

As the *Product* of the *Half Sum of the Sides*, and *Friſt Remainder*, is to the *Product* of the other *Two Remainders*; ſo is the *Square of Radius* to the *Square* of the *Tangent* of half the *Angle* oppoſite to that *Firſt Remainder*.

Prob. 8. Caſe 6. *Three Sides given; to find an Angle.*
Example. In the Triangle BCD. *Plate* 2. *Fig.* 8.

The *Side*	BC 105	Feet given :	Angle	BDC	req.
	BD 85			BCD	
	CD 50			CBD	

This Triangle is made by *Prob.* 17. of *Geometry.*
The Operation for the Angle CBD is

Side BC	105	The half Sum *Leag.* 120. *co. ar.*	7.920819
BD	85	The Firſt *Remainder* — 70. *co. ar.*	8.154902
CD	50	The other 2 *Remain.* 35 Logar.	1.544068
Sum of *Sides*	240	15 Logar.	1.176091
½ their Sum	120	Sum	18.795880
From ½ *Sum*	70	Tangent 14d. 02m. — ½ *Sum*	9.397940
Subt. each ſide	35	Doubled 14d. 02m.	
there remains	15	Produceth 28d. 04m. for CBD req.	

This *Axiom* finds an Angle at one Operation, yet not being applicable to the Inſtrumental way of working Proportions, you have this fourth *Axiom* in other Terms; which finds an Angle at two Proportions, and may be wrought both Inſtrumental and Logarithmetical.

Axiom 4. Uſeful, when three Sides of a Triangle are given; to find an Angle.

As the Longeſt Side, is to the Sum of the two ſhorteſt; ſo is the Difference of the two Shorteſt, to the Difference of the Segment of the Baſe or Longeſt Side.

Note; Let fall a *Perpendicular* (from the *Angle* oppoſite) to the *Longeſt Side*, which divideth it into two *Segments*; and the *Oblique-Triangle* into two *Right-Angle-Triangles*.

As in the aforeſaid Triangle BCD. *Plate* 2. *Fig.* 8.

Let fall the *Perpendicular* DA, which makes the *Segments* of the *Baſe* to be BA, and AC, and the two *Right-Angle-Triangles* BAD, and CAD, and the Difference of the Segments BE.

1. To find BC the Difference of the Segments of the Baſe.

Shorteſt Sides ——— ——— { BD ——— 85 Feet
{ CD ——— 50 Feet
Added, is the Sum of the two Shorteſt Sides— 135 Feet
Subtracted is their Difference ——— —— 35 Feet

Then as the Side BC, is to the Sum of BD and CD; ſo is the Difference of BD and CD, to BE the Difference of the Segment BA and AC. Or thus,

Side BC .. *Sum* BD&CD : : *Diff*. BD&CD .. BE the *Diff* of Seg:
105 Feet .. 135 : : 35 Feet .. 45 Feet.

The Side BC 105 Feet,
Diff. *Segment* BE 45 Feet
Added is ——— 150 } the half is { 75 BA the greater } Seg-
Subtracted is — 60 } { 30 AC the leſſer } ment.

2. The Angles BCD or CBD, may be found by the 4th *Caſe* of *Right-angle Triangles*; Thus,

Hypot. BD .. *Radius* : : *Leg* AB .. S. ADB.
85 *Feet* .. S. 90d. : : 75 *Feet* .. S. 61d. 54m.
Which ſubtracted from ——— ——— 90d. 00m.
Remainder is the Angle CBD —— 28d. 06m. as before.

Thus much for *Plain Triangles*; and to compleat *Trigonometry*, *Spherical* ſhould be next. But I count the Application of this before the *Doctrine* of that, moſt conducible to the *Learners Proficiency*: Therefore will deſcend to the neceſſary Uſes of *Plain Trigonometry* in *Plain* and *Mercator*'s Sailing, which will make way for *Spherical Trigonometry.*

CHAP. III. *Plain Trigonometry applied in Problems of Sailing by the Plain* Sea-Chart, *commonly called* Plain-Sailing.

AND that nothing may be wanting to the Accompliſhment of *Navigation,* I will begin with the *Julian Kalendar,* and then the Uſe of the *Plain-Chart,* before I apply *Plain-Trigonometry* to *Plain Sailing.*

Section I. *The common Notes of the* Julian Kalendar; *to find the* Prime, Epact, Dominical Letter, Eaſter Day, *the* Moon's Age, Southing, *and time of* High-water.

Prob. I. *To find the Golden Number, Cycle of the Sun, and* Roman *Indiction.*

Definitions, 1. THE *Golden Number* or *Prime,* is a Circular Revolution of 19 Years; in which Space of time (it has been ſuppoſed) the Sun and Moon finiſh all their Variety of Aſpects.

2. The *Cycle,* or *Circle of the Sun,* maketh its Revolution in 28 Years; in which time all the Variety of *Dominical Letters,* and *Leap-Years* expire, and the 29th Year the Circle begins again; which Number ſerves to find the *Dominical Letter* for any Year, paſt, preſent, or to come.

3. *Roman Indiction* conſiſteth of 15 Years: for once in 15 Years the Nations were to pay Tribute to the *Romans*; a thing now out of Uſe with us.

The Rule out of Mr. Street's *Memorial Verſes on the Eccleſiaſtical and Civil Kalendar.*

When 1, 9, 3, to th' Year hath added been;
Divide by 19, 28, 15.

Examp. I would know the *Golden Number, Cycle* of the *Sun* and *Roman Indiction* for the Year 1732.

The Operation.

The Year	1732	1732	1732
Add	1	9	3
Sum is	1733	1741	1735
	19) — (91	28) — (62	15) — (115
	23	61	23
	(4)	(05)	85
			10

For the Year 1732	Golden Number	is	04
	Cycle of the Sun		05
	Roman Indiction		10.

Prob. II. *To find the Epact for any Year.*

Definition. The Epact is 11 Days, the Year of the *Moon* acketh of the *Sun*'s Year: The *Lunar* being 354 Days, and the *Solar-Year* 365 Days.

Note; The Epact never exceedeth 29, and alters every Year 11, and is uſed to find the *Moon's Age* and *Eaſter Day.*

Alſo, *Note*, The *Prime* changeth the *Firſt* of *January*, but he *Epact* the *Firſt* of *March*. *The Rule is,*

1. Find the *Golden Number* by *Prob.* 1.
2. Divide the *Golden Number* by 3, and note the Remainder.
3. Multiply the Remainder by 10, and note the Product.
4. To that Product add the *Golden Number*; the Sum (if it xceeds not 30) is the Epact; but if it doth, ſubtract 30 herefrom, and the Remainder is the Epact.

Examp. For the Year 1732: I demand the Epact?

To the Year 1732 add 1, and the Sum is 1733, which diide by 19 and the Quotient is 91, and the Remainder is 4; o that the Golden Number is 4, which divide by 3, the Quotient is 1.

nd the Remainder is ——— 1
ultiply by ——— 10
he Product is ——— 10
o it add the Golden Number —— 4
he Sum is the Epact ——— 14 for the Year 1732.

Prob. III. *To know if it be Biſſextile or Leap-Year.*

Definition. Leap-year is every Fourth Year, and ſo called from it's Leaping a Day more that Year than in a common Year; for in the common Year any fixed Day of a Month changeth ſucceſſively the Day of the Week; but in the *Leap-Year,* it Skips or Leaps over one Day.

Note, The *Common Year* hath 365 Days in it, but *Leap-Year* 366, and then *February* hath 29 Days, which in *Common Years* hath but 28 Days,

The Rule. Divide the Year by 4, what's left ſhall be,
For *Leap-Year* 0, for paſt 1, 2, or 3.

Example. The Year 1732; what is it, a *Common-Year,* or *Leap-Year?*

4)1732(433 Quotient, and Remainder is 0; ſo that the
(0 Year 1732 is *Leap-Year.*

Prob. IV. *To find the Dominical Letter for any Year.*

Definition 1. The Week Days in *Kalendars* or *Almanacks* are expreſſed by the firſt ſeven Letters of the Alphabet, and one of them is a Dominical Letter.

2. *Dominical Letter,* or *Lord's Day Letter,* is that which ſtands for it, commonly called *Sunday.*

The Rule. Divide the Year, it's 4th, and 4, by 7;
What's left, ſubtract, from 7; the Letter's given.

Note 1. When it's *Leap Year* there are two *Dominical-Letters*; one ſerves to the 25th of *February,* the other from thence to the Years end.

2. The *Dominical-Letter* goeth backward in a *Common-Year* one Letter, but in Leap-Year two Letters.

3. The *Leap-Year* having two *Dominical-Letters,* its the latter of them that this Rule finds.

Examp. For the Year 1732: I demand the *Dominical-Letter*

The Operation.

The given Year (by *Prob,* 3.) is a Leap Year ——— 1732
It's ¼ Part is ——————————— 433
To it add ——————————— 4

The Sum is ——————————— 2169

7)2169(309 Quotient, and Remainder is 6; which
(6 ſubtract from 7, reſts 1 for the Dominical Letter; that is, A; but the Year 1732 being Leap-Year hath two Dominical Letters which are BA.

Prob. V. *By the 19 Epacts; to find Eaſter-Limit from the beginning of* March *incluſively.*

Definitions 1. *Eaſter-Limit* is the 14th Day of the *Paſchal New-Moon* (or the New-Moon neareſt the *Vernal Equinox)* after the Firſt of *March.*

2. The *Vernal Equinox,* is ſuppoſed to be fixed to the 21ſt of *March.*

3. *Eaſter-Day,* is the Sunday after the 14th Day of the *Paſchal-New Moon*; and is never before the 22d Day of *March,* nor after the 25th Day of *April.*

The Rule 1. Find the Epact by *Prob.* 2,
2. The Epacts take from 47; but 2:
The greateſt take from 77; 'twill do.

Example. I demand *Eaſter-Limit* for the Year 1732.

The Operation.

The Epact for the Year 1732 (by *Prob.* 2.) is —— 14
Which ſubtract from ———— 47

Remainder is *Eaſter-Limit* from the 1ſt of *March* 33 Days
hat is, the 12th Day of *April* for the Year 1732.

Prob. VI. *To find* Eaſter-Day *for any Year.*

Definition. *Eaſter-Day,* is next *Sunday* after *Eaſter-Limit,* or he 14th Day of the *Paſchal New-Moon.*

Note; *Eaſter Day* is not leſs than 22 Days, nor more tha 6 Days from the Firſt of *March.*

The Rule. 1. Find the *Dominical-Letter* by *Prob.* 4.
2. And *Eaſter-Limit* by the laſt Problem,
3 The Letter more by 4 from Limit take;
What's left from neareſt 7s ſhall *Eaſter* make,

Examp. For the Year 1732, I demand *Eaſter Day*.

The Operation.

Dominical Letter (by *Prob*. 4) is BA or —————— 1
To it add —————————————— 4

The Sum is —————————————— 05
Which ſubtract from *Eaſter Limit* (found by *Prob*. 5.) —— 33

Remainder is —————————————— 28
Which ſubtract from neareſt 7s —————————— 35

Remainder is —————————————— 7
Which added to *Eaſter Limit*, is *Eaſter Day* ———— 33

That is 40 Days from the Firſt of *March*, which makes the 9th of *April Eaſter Day*, for the Year 1732.

Prob. VII. *To find the Moon's Age*.

Definition. The Moon's Age is how many Days are paſt ſince the Day of her Change, which Age never exceeds 30 Days.

The Rule, 1. Find the Epact by *Prob*. 2.

2. To the Epact add the Day of the Month, and the Number of the Month; the Sum if it exceeds not 30, is her Age; but if it doth, ſubtract 30 ſo oft as you can, and the Remainder is her Age.

Note, The Numbers of the Months are theſe,

January,	*February*,	*March*,	*April*,	*May*,	*June*,
0,	2,	1,	2,	3,	4,
July,	*Auguſt*,	*September*,	*October*,	*November*,	*December*,
5,	6,	8,	8,	10,	10,

Examp. The 20th of *May* 1732. I demand the Moon's Age?

The Operation.

The Epact (by *Prob*. 2.) for the Year 1732 is ———— 14
To it add the Day of the Month ———————— 20
And the Month *May*'s, Number is ———————— 3

The Sum is —————————————— 37 Days
Which being more than 30 by ———————— 07 Days
is the Moon's Age required.

Prob. VIII. *To find the Moon's Southing*.

Definition. The *Moon's Southing*, is the time of her coming to, or upon the *Meridian*; which from the *New Moon* to her *Full*, is after Noon, but from the *Full* to the *Change*, is before Noon.

The Rule. 1. Find the Moon's Age by the laſt *Problem.*

2. Multiply her Age by 4, and divide the Product by 5; the Quotient is Hours, and the Remainder is ſo many times 12 Minutes of an Hour, and both is her Southing.

Example. The 20th of *May*, 1732; I demand the Moon's Southing?

The Operation.

The Moon's Age (by *Prob.* 7.) is ——— 7 Days

Multiply by ——————— 4

The Product is ——————— 28

That divided by 5, the Quotient is 5 Hours, and the Remainder is 3, which makes 36 Minutes; ſo that the Moon's Southing is 5 Hours, 36 Minutes Afternoon.

Prob. IX. *To find the Time of Full Sea, or High-water at any Place*

The Rule 1. Find the Moon's Southing by the laſt *Problem.*

2. To the Southing, add the Point of the Compaſs making Full Sea, (on the Full and Change Day) for the Place propoſed; the Sum is the Time of Full Sea, or High-water.

Note; The Point of the Compaſs making Full ſea on the Full and Change Day, may be found in the *Tide-Table* in the *Mariner's Kalendar.*

Examp. The 20th of *May* 1732; I demand the time of *High-water* at *London*?

The *Operation.* The Moon's Southing (by *Prob.* 8.) for the 20th of *May*, 1732. is ——————— 5h. 36m. Afternoon

To it add *London* S W. and NE. ——— 3h. 00m.

The Sum is time of High-water ——— 8h. 36m. Afternoon

Sect. II. *The Uſe of the* Plain-Chart, or Plot.

IT's requiſite to underſtand the *Plain Chart* before the Caſes of *Plain Sailing*; for that contributes much to the underſtanding this: And for the better underſtanding of it, mind theſe following.

Definition 1. The *Plain Chart* ſuppoſeth the Earth and Sea to make one *Flat Superficies*, or *Long ſquare*; in which the Meridians are Parallel, and the Degrees of Latitude and Longitude, Equal in all Places; which is only true in the Equator.

2. The *Equator*, is a Line drawn Eaſt and Weſt, and is 90 degrees diſtant from each Pole: From it Latitude beginneth, and in it Longitude is counted.

3. The *Poles* are two oppoſite Points, one called the North Pole, the other the South Pole; and lie North and South from each other; at them is the greateſt Latitude 90 Degrees.

4. The *Meridians*, are Lines (in this Chart) parallel to each other, and perpendicular to the Equinoctial, and lie North and South; on which are counted the Degrees of Latitude.

5. *Parallels of Latitude*, are Lines parallel to the Equator, and lie Eaſt and Weſt.

6. *Latitude*, is the Breadth or Diſtance of any Parallel of Latitude from the Equator; from whence it's counted both ways to each Pole, ending in 90 Degrees, the greateſt Latitude.

7. *North-Latitude*, is on that ſide of the Equator towards the North Pole; and South Latitude towards the South Pole.

8. *Difference of Latitude*, is the Breadth, or neareſt Diſtance of any two Parallels of Latitude; and ſheweth how far one Place lies to the Northward, or Southward of the other; it never exceedeth 180 Degrees.

9. *Longitude* (in the *Plain-Chart*) is reckoned on any Parallel of Latitude, and encreaſing to the Eaſtward till it end in 360 Degrees, the greateſt Longitude.

10 *Difference of Longitude, Meridional Diſtance, Departure from the Meridian*, ſignifie (*in the Plain Chart*) one and the ſame thing, and is the neareſt Diſtance of any two Meridians; it ſheweth how far one Place is to the Eaſtward or Weſtward of another.

The Uſe of the Plain-Chart.

Problem 1. *To find the Latitude of any Place in the* Chart.

Rule 1 Take the neareſt Diſtance of the Place to any Parallel, or Eaſt and Weſt Line.

2. Lay the Diſtance on the graduated Meridian, ſetting one Foot of the Compaſſes in the ſaid Parallel, and turning the other Foot the ſame way, the propoſed Place lieth from it; the laſt ſheweth the Latitude required.

Examp

Example. What Latitude doth the *Lizard* in *England* lie in?

1. Take the neareſt Diſtance from the *Lizard* to any Parallel or Eaſt and Weſt Line.

2. Lay that Diſtance (on the Graduated Meridian) from the ſaid Parallel, and the moveable Foot ſheweth 50 Degrees the Latitude of the *Lizard*; and it is North Latitude, becauſe Northward of the Equator: Do ſo for any other Place.

Prob. 2. *To find the Courſe or Bearing of one Place from another.*

The Rule is thus,

1. Lay a Ruler on the two Places given; and take the neareſt Diſtance from the Center of any Compaſs to the Ruler's Edge.

2. Slide the Compaſſes, (being at that Diſtance) with one Foot cloſe to the Ruler, and the other Foot Perpendicular to it; in ſo doing the Perpendicular Foot Points out (among the Rumb-lines) the Courſe or Bearing of the propoſed Places, from one another.

Example, I demand the Courſe from the *Lizard* in *England,* to the Iſland *Berbadoes.*

1. Laying a Ruler's Edge on the *Lizard* and *Berbadoes,* take the neareſt Diſtance from the Center of a Compaſs to the edge of the Ruler.

2. Slide the Compaſſes along by the Ruler, keeping one Foot perpendicular to it, and it ſheweth among the Rumbs the Courſe to be S W. ½ W. neareſt, from the *Lizard* to the Iſland *Berbadoes,* the oppoſite point (*viz.*) N. E. ½ E. is the Courſe from *Iſland Berbadoes* to the *Lizard.*

Prob. 3. *To find the Diſtance of one Place from another.*

The Rule. Extend the Compaſſes from one Place to another. Meaſure that Diſtance on a Scale of Leagues, or on the Graduated Meridian; the firſt ſheweth the Diſtance in Leagues; the latter in Degrees. This is ſo eaſy, it needs no Example.

Problem 1. *To find the Meridional Diſtance, or Departure between any two Places in the* Chart.

The Rule. 4. Take the neareſt Diſtance from one of the given Places, to any Meridian.

2. The Compaſſes being kept at that Diſtance, move them Perpendicular) along that Meridian, till you bring both Feet of the Compaſſes into the Parallel of the other Place, there ſtay the Compaſſes.

3. The Diſtance from the Perpendicular Foot to the other propoſed Place, being meaſured on the Graduated Meridian, or on the *Scale of Leagues* giveth the *Meridional Diſtance* required.

Examp. I demand the Meridional Diſtance between the *Lizard* and Cape *Finiſterre?*

1. Take the neareſt Diſtance from the *Lizard* to a Meridian, and ſlide the Compaſſes with one Foot on it, and the other Perpendicular, till both Feet come to the Parallel of Cape *Finiſterre.*

2. Then the Diſtance from the Perpendicular Foot, to *Cape Finiſterre*, being meaſured on the Meridian, is 3 Degrees, 18 Minutes, or 66 Leagues is the Meridional Diſtance, and ſheweth *Cape Finiſterre* is 66 Leagues to the Weſtward of the Meridian of the *Lizard.*

Prob. 5. *The Latitude a Ship is in, and her Meridional Diſtance given; to find in the Chart where the Ship is.*

The Rule. 1. Lay off the Meridional Diſtance (according to its Nature, whether to the Eaſtward or Weſtward) from the Place it's counted from; and then the neareſt Diſtance, from that to any Meridian, muſt be kept in one Pair of Compaſſes.

2. With another Pair of Compaſſes, take the neareſt Diſtance of the Latitude from any Parallel, or Eaſt and Weſt Line.

3 Then move both Pair of Compaſſes perpendicular, one on the Meridian, the other on the Parallel, 'till both Perpendicular-Feet meet, and there is the Place in the *Chart* repreſenting the Place required.

Sect. III. *Plain Trigonometry applied in* Plain-Sailing.

Definitions. 1. *Navigation*, is the guiding or directing a Ship (thro' the Ocean) from one Place to another; it's divided into two Generals; Domeſtick and Remote.

2. Domeſtick or Home Navigation, is Coaſting or Sailing along ſhore; in which the *Mariners Compaſs*, and *Lead*, are the chief Inſtruments.

3. *Remote* (which more properly bears the Name of *Navigation)* is the Conducting a Ship to any Port, and the finding what Latitude and Longitude ſhe is in at any time; in the Practice of which, the *Mariners* have theſe helps, the *Compaſs*, the *Log*, and the *Latitude*.

4. The *Compaſs* is a Circle divided into 4 Quadrants, Quarters, or principal Points; Eaſt, Weſt, North and South; each Quarter into 8 equal Parts, being in all 32 Rumbs or Points, as in *Figure* 16. of *Plate* 2. So that ſteering by the Compaſs (well made and duly rectified) is known how, or which way the Ship ſails to a ſmall matter.

5. The *Log-line* (truly marked, or ſome other good way) is the Inſtrument whereby the *Mariners* meaſure the Ships Diſtance ſailed, in *Minutes, Miles*, or *Leagues*, every Hour, Watch or Day.

Note, Each Knot in the *Log-line* ought to be 50 Feet from each other, and not 42 Feet or 7 Fathom; an Error too frequent among the *Engliſh Navigators*, and long ſince refuted by Mr. *Norwood* in his *Seaman's Practice*.

Alſo the ½ *Minute Glaſs*, uſed with the *Log-Line*, ought to be truly 30 Seconds of Time, and not 25 or 26 Seconds, as too many which are ſo called.

6. The *Third Help*, is the Knowledge of the Latitude, from whence he ſails, to which he is bound, and where the Ship is at any Time; this is attained by *Cœleſtial Obſervation* (at Sea with a *Quadrant* or *Foreſtaff*) taking the Sun or Star's Meridional Altitude.

Now by any two of theſe Three Things exactly known, the *Navigator* comes to know at any time, where he is, how far he hath Run, and how far he is yet to Run, which way, or upon what Point of the Compaſs he is to Steer; and all this by *Trigonometry*, in the three Kinds, *viz.*

Plain-Sailing, *Wright's-Sailing*, and *Circle-Sailing*; as ſhall be ſhewed in order: And firſt of *Plain Sailing*, in which take theſe *Five General Rules* following.

Rule 1. That 20 Leagues being equal to 60 Miles or Minutes, is alſo equal to one Degree of Latitude.

But *Note*, One of theſe Miles or Minutes containeth 6000 Feet, and is greater than a *Statute* or common Mile, which is but 5000 Feet; of which about 69½ Miles makes a Degree; whereas in the Practice of *Navigation*, 60 are counted to a Degree on the Meridian, or any great Circle.

2. *General Rule,* To find the Difference of Latitude, when the Latitudes of two Places are given.

The Latitudes $\left\{\begin{array}{l}\text{both}\\ \text{one}\end{array}\right\}$ *North* $\left\{\begin{array}{l}\text{or both}\\ \text{theother}\end{array}\right\}$ *South* $\left\{\begin{array}{l}\text{ſubtract}\\ \text{add}\end{array}\right\}$ finds the Difference of Latitude.

3. *General Rule.* To find the Latitude the Ship is in, when the Latitude ſailed from, and the Difference of Latitude is given; for this are the two following Caſes.

Caſe I.

In $\left\{\begin{array}{l}\textit{North}\\ \textit{South}\end{array}\right\}$ Latit. ſailing to the $\left\{\begin{array}{l}\textit{North}\\ \textit{South}\end{array}\right\}$ *ward* the Latitude increaſeth, add.

Caſe II.

In $\left\{\begin{array}{l}\textit{North}\\ \textit{South}\end{array}\right\}$ Latitude, ſailing to the $\left\{\begin{array}{l}\textit{South}\\ \textit{North}\end{array}\right\}$ *ward* the Latitude decreaſeth, ſubtract.

And here *Note,* When the Latitude decreaſeth, and the Difference of Latitude is greater than the Latitude ſail'd from, the Ship hath croſſed the Equator, and changed her Latitude; either from North into South, or South into North.

4. *General Rule.* The Sum of the three Angles of every Plain Triangle, is equal to 16 Points of the Compaſs: For

$$\left.\begin{array}{l}\text{1 Point}\\ \left.\begin{array}{r}8\\16\\32\end{array}\right\}\text{Points}\end{array}\right\}\text{of the Compaſs is equal to}\left\{\begin{array}{l}\text{11d. 15m;}\\ \left.\begin{array}{r}90\\180\\360\end{array}\right\}\text{Degrees.}\end{array}\right.$$

5. *General Rule.* If a Ship ſails Eaſt or Weſt, ſhe keeps in the ſame Latitude; and if a Ship ſails North or South, ſhe keeps in the ſame Longitude.

Note, Plain Sailing is divided into three Parts, *viz.*

1. In a *Right Angle Triangle*, relating to a Single Courſe, in which are *Six Caſes.*

2. In a *Right-Angle-Triangle*, relating to ſeveral Courſes called a *Traverſe.*

3. In an *Oblique Triangle*, in which are but four Caſes, tho' multitude of various Queſtions.

The *Firſt Part of Plain Sailing* is contained in the ſix *Problems* or *Caſes* following.

Prob. or Caſe 1. *Courſe and Diſtance Sailed given; to find the Difference of Latitude and the Departure from the Meridian.*

Example. Admit a Ship runs 496 Minutes S W by W. from the *Lizard* in 50d. 00m. North Latitude: I demand the Latitude ſhe is in, and how far ſhe is departed from the Meridian?

Obſerve. That in all *Problems of Navigation*, make the upper end of the Book or Slate to be the North; then the Right hand is the Eaſt, the Left hand the Weſt, and the lower End is the South. Then,

To delineate the Problem *by the* Plain-Scale.

1. Draw the Meridian AB (*Plate* 2. *Fig.* 9.) towards the Right-hand, when the Courſe is Weſterly, but when Eaſterly towards the Left-hand; and put A at the upper End when the Courſe is Southerly, but at the lower end when its Northerly.

2. With a Chord of 60 Degrees and one Foot on A, deſcribe an Arch; on that Arch lay 5 Rumbs (becauſe S W by W. is 5 Points from the South) taken from the Scale of Rumbs, and by it draw a Line AC.

3. From any *Scale of equal Parts*, take the Diſtance run 496 Minutes, and lay it from A to C; then A repreſents the Place ſailed from, C the Place the Ship is come to.

4. From C let fall the Perpendicular CB, to cut the Meridian in B, and it's done. Then, meaſure AB and BC on the ſame *Scale of Equal Parts*, that AC was taken from, will ſhew how much the Difference of Latitude, and Departure from the Meridian is, by the *Plain Scale.*

Theſe Directions, with the following Explanation being well conſidered, will ſhew how to delineate and anſwer any of the *Six Caſes of Plain-Sailing* by the *Plain-Scale*: Therefore I omit the Delineations in the five following Caſes: having given ſufficient Directions to make any Rectangle Plain-Triangle in *Prob.* 10, 11, 12, and 13 of *Practical Geometry*, and ſuch are all the Caſes in this Part of *Plain-Sailing.*

This Right Angle Triangle ABC (*Plate* 2. *Fig.* 9.) may be made by *Prob.* 10. of *Geometry*; in which *Note*;

1. The Hypotenuſe AC (repreſents the Point of the Compaſs the Ship ſteered, and) the Ship's Diſtance run.
2. The Leg AB, (the Meridian) that is, the North or South Point of the Compaſs the Difference of Latitude.
3. The Leg BC (the Eaſt or Weſt Point of the Compaſs and a Parallel of Latitude) the Departure from the Meridian.
4. The Angle BAC (the Angle of) the Ship's Courſe.
5. The Angle ACB (the Angle of) the Complement of the Ship's Courſe.

Note, The Angle that the Point of the Compaſs (ſteered by or upon) maketh with the Meridian, or North, and South Point of the Compaſs, is called the *Angle of the Ship's Courſe*, and the Angle it maketh with the Eaſt, or Weſt Point, is the Complement of the Courſe.

The Courſe in this *Example* being S. W. by W. is 5 Points from the South or Meridian, and makes 56d. 15m. *The Complement of the Courſe* is 3 Points; that is, 33d. 45m. as may be ſeen in the Table, Intituled, *A Table of the Angles which every Rumb (or Point of the Compaſs) maketh with the Meridian.* At the End of this Book.

The Things thus explained, the Proportion by *Chapter* 2, *Section* 2. *Axiom* 1. and Caſe 1. of *Plain Right Angle-Triangles* may be as follows.

For the Difference of Latitude, three ways, thus:

$$\left.\begin{array}{l}\text{Radius}\\ \text{Sec. Courſe}\\ \text{Sec. c. Courſe}\end{array}\right\} \text{.. Diſtance ::} \left\{\begin{array}{c}\text{S.c. Courſe}\\ \text{Radius}\\ \text{T.c.Courſe}\end{array}\right\} \text{.. Diff. Lat.}$$

All theſe three Proportions may be wrought by the Logarithms, but I only work the firſt.

By Gunter's *Scale, thus,*

Radius .. Diſtance : : S. c. Courſe .. Difference Latitude.
S. 8 Points .. 496 Min. : : S. 3 Points .. Min. 275.6 Tenths.
Latitude ſailed from is—— —— 50d. 00m. North.
The Diff. of Latitude Min. 275.6 or — 04d. 36m.

Subtract, giveth Latitude the Ship is in 45d. 24m North

2. For

For the Departure, three ways, thus ;

$$\left.\begin{array}{l}\text{Radius}\\ \text{Sec Courſe}\\ \text{Sec.c Courſe}\end{array}\right\} \text{.. Diſtance : :} \left\{\begin{array}{l}\text{S. Courſe}\\ \text{T. Courſe}\\ \text{Radius}\end{array}\right\} \text{.. Departure.}$$

The firſt of theſe by Gunter's *Scale, thus ;*

Radius .. Diſtance : : S Courſe .. Depart. from the Merid.
S. 8 Points .. 496 Min. : : S. 5 Points .. Minutes 412.4 Tenths.

So that the Departure from the Meridian is Minutes 412.4 Tenths, which makes 6d. 52m. Meridian Diſtance Weſt.

Problem *or* Caſe 2. *Courſe and Difference of Latitude given ; to find the Diſtance run, and the Departure from the Meridian.*

Example. If a Ship runneth SE by E. from 1d. 45m. North Latitude, and then by Obſervation is in 2d. 50m. South Latitude, What is her Diſtance and Departure ? *Plate* 2. *Fig.* 10.

This Triangle ABC may be made by *Prob.* 12. of *Geometry.*

In this *Example*, having Latitude the Ship ſailed from, and Latitude ſhe is in by Obſervation, there are the Latitudes of two Places given, and by the *Second General Rule*, in *Page* 58, the Difference of Latitude is found as followeth.

Latitude ſailed from ——— — ——— 1d. 45m. North
Latitude by Obſervation is ——— —— 2d. 50m. South

The Difference of Latitude is ——— —— 4d. 35m. or 275 Minutes; found by multiplying by 60, the Minutes in a Degree

1ſt, For the Diſtance the Proportion may be thus ;

S c. Courſe .. Diff. Lat. : : Radius .. Diſtance.
S. 3 Points .. 275 Min. : : S. 8 Points .. 495 Minutes.

2d, For the Departure, thus,

S.c. Courſe .. Diff. Lat. : : S. Courſe .. Departure.
S. 3 Points .. 275 Min. : : S. 5 Points .. 412 Minutes : Or 6d. 52m. Eaſting ; that is, the Ship is ſo much to the Eaſtward of the Meridian of the Place ſhe ſailed from.

Problem *or* Caſe 3. *Courſe and Departure from the Meridian given ; to find the Diſtance and Difference of Latitude.*

Example If a Ship ſails NE. by E. from a Port in 3d. 15m. South Latitude, until ſhe depart her firſt Meridian 412 Min. I demand her Diſtance, and what Latitude ſhe is in ? *Plate* 2. *Fig.* 11. This Triangle may be made by *Prob.* 12. of *Geometry.*

1. *For*

1ſt, For the Diſtance, the Proportion may be this.

S. Courſe .. Departure : : Radius .. Diſtance Run.
S. 5 Points .. 412 Min. : : S. 8 Points .. Min. 495.5 Tenths

2d, For the Difference of Latitude thus ;

S. Courſe .. Departure : : Sc. Courſe .. Diff. Latitude.
S. 5 Points .. 412 Min. : : S. 3 Points .. 275 Minutes, which being reduced is 4 Degrees 35 Minutes Northing, by which find the Latitude the Ship is in, as here-under.

Latitude ſailed from is ———— 3d. 15m. South
Difference of Latitude is 275 Min. or — 4d. 35m. North

Subtract, giveth Latitude the Ship is in 1d. 20m. North

Prob. *or* Caſe 4. *Diſtance, and Difference of Latitude given ; to find the Courſe and Departure.*

Example. Suppoſe a Ship Sails 496 Min. between the South and the Weſt, from a Port in 2d. 48m. South Latitude ; and then by Obſervation is in 7d. 23m. South Latitude : What Courſe hath ſhe ſteer'd, and what Departure hath ſhe made? *Plate* 2. *Fig.* 12. This Triangle may be made by *Prob.* 11. of *Geometry.*

By the two Latitudes mentioned in this *Example*, find the Difference of Latitude, as followeth,

Latitude ſailed from is ——— 2d. 48m. South
Latitude by Obſervation, is —— 7d. 23m South

Subtract, gives the Diff. of Lat. 4d. 35m. or 275 M.

1ſt, For the Courſe, the Proportion is,

Diſtance .. Radius : : Diff. Lat. .. Sc. Courſe.
496 Min. .. S. 90d. : : 275 Min. .. S. 33d. 40m.

Which ſubtract from 90d. the Remainder 56d. 20m. is the Courſe, which makes 5 Points neareſt ; or S W by W. for the Ships Courſe.

2d, The Proportion for the Departure is,

Radius .. Diſtance : : S. Courſe .. Departure.
S. 90d. .. 496 Min. : : S. 56d. 20m. .. 412 Minutes.

Prob. *or* Caſe 5. *Diſtance and Departure given ; to find the Courſe and Difference of Latitude.*

Example. Admit a Ship Sails 496 Minutes between the North and the Weſt, from the Iſland *Bermudas*, in Latitude 32d 30m. North, until her Departure is 412 Minutes ; what Courſe hath ſhe ſteer'd ? And what Latitude is ſhe in ? *Plate* 2. *Fig.* 13. This Triangle may be made by *Prob.* 11, of *Geometry*.

1ſt, For the Courſe take this Proportion.

Diſtance .. Radius :: Departure .. Sc. Courſe.
496 min. .. S. 90d. :: 412 min. .. S. 56d. 10m. N. weſterly.
That is, 5 Points, which makes the Courſe to be N W by W.

2d, For the Difference of Latitude.

Radius .. Diſtance : : Sc. Courſe .. Difference of Latitude
S. 90d. .. 496min. : : S. 33d. 40m. .. 275 min. or 4d. 35m.

	d.	m.	
Latitude ſailed from	32	30	North
Difference of Latitude 275 Minutes, or	4	35	
Latitude Ship is in	37	05	North

Prob. or Caſe 6. *Difference of Latitude and Departure given ; to find the Courſe and Diſtance.*

Example. If a Ship's Southing be 275 Minutes, and her Eaſting 412 Minutes, What is her Courſe and Diſtance ? *Plate* 2. *Fig.* 14. This Triangle may be made by Prob. 13. of *Geometry*.

1ſt, For the Courſe take this Proportion.

Diff Lat. .. Departure : : Radius .. T. Courſe
275 Min. .. 412 Min. : : T. 45d. .. T. 56d. 17m. South Eaſterly, or 5 Points, which makes the Courſe to be SE. by E. neareſt.

2d, For the Diſtance this Proportion.

S. Courſe .. Departure : : Radius .. Diſtance.
S. 56d. 17m. .. 412 Min. : : S. 90d. .. 495 Min.

Theſe ſix preceeding *Problems* are the common Caſe of *Plain Sailing* ; which the Learner ought to be well acquainted with: and for that End I here add ſix more for Practice, whoſe Anſwers may be found by the foregoing Rules.

Queſt. 1. *A Ship in* 2d. 10m. *South Latitude ſails N. by E.* 89 *Leagues : What Latitude is ſhe in ; And what is her Departure?*

Anſw. Latitude 2d 12m. North, and Departure Leagues 17 and 35 parts of a Hundred.

Queſt. 2. *A Ship ſailing S S W. from a Port in* 41d. 30m. *North Latitude ; and then by Obſervation, the Ship is in* 36d. 57m. *North Latitude : I demand the Diſtance Run, and Departure ?*

Anſw. Diſtance Run, 98 Leagues 5 Tenths, Departure Leagues 37,6 Tenths.

Queſt. 3. *A Ship ſails S. S. W. half W. from* 2d. 30m. *South*

Latitude until the Departure be 59 Leagues: I demand her Diſtance Run, and the Latitude ſhe is in?

Anſw. Diſtance Run 125 Leagues, Latitude 8d. 01m. South.

Queſt. 4. *If a Ship Saileth 360 min. South Weſtward, from 21d. 59m. South Latitude, until (by Obſervation) ſhe be in 24d. 49m. South Latitude: What is her Courſe and Departure?*

Anſw. Courſe is S W by W. ½ W. and Departure from the Meridian is 318 Minutes.

Queſt. 5. *Suppoſe a Ship Saileth 354 min North Eaſtward; from 2d. 9m. South Latitude, until her Departure be 150 min. What is her Courſe, and Latitude ſhe is in?*

Anſw. Courſe is N N E. ¼ Eaſt neareſt, and Latitude the Ship is in, is 3d. 8m. North.

Queſt 6. *Sailing between the North and the Weſt, from a Port in 1d. 59m. South Latitude, and then arriving at another Port in 3d. 08m. North Latitude, which is 209 min. to the Weſtward of the firſt Port: I demand the Courſe, and Diſtance from the firſt Port to the ſecond?*

Anſw. Courſe is NW by N. and Diſtance of the Ports 371m. or Leagues 123⅔.

So much for the Firſt Part of *Plain-Sailing, Traverſe* is next in order.

Sect. IV. *Plain Sailing the ſecond Part; ſhewing how to reſolve a Traverſe, or bring ſeveral Courſes into one.*

HAving learn'd thoſe neceſſary *Problems* concerning a Single Courſe, the next in order is a *Compound Courſe*, commonly called a *Traverſe*; in order to the Right underſtanding thereof, obſerve the following Definitions.

1. A *Traverſe*; is when a Ship (meeting with a contrary Wind) ſaileth on ſeveral Courſes in 24 Hours.

2. *To reſolve a Traverſe*, is to reduce or bring ſeveral Courſes into one; the Courſes are known by the Compaſs, and the Diſtance by the Log; which in common Voyages is heav'd once in two Hours, but to the *Eaſt Indies* every Hour.

3. The *Log*, is a Piece of Board about ſeven Inches Long, in Form like a Flounder, the Head off, and ſo faſtned to a ſmall Chord (or Line call'd the *Log-Line*) at one End, with ſo much Lead at the other, that when it's put into the *Sea*, it may ſwim upright or endwiſe.

4. The *Log Line* is divided into equal Spaces, called *Knots*,

by

Pla: 2.

Fig. I.

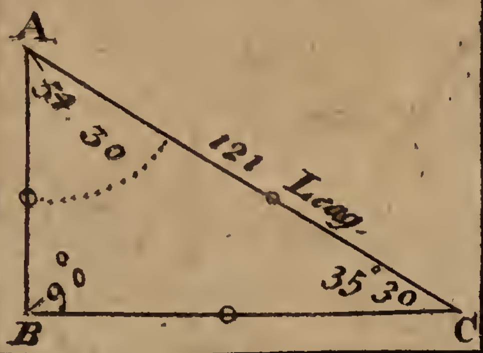


Fig. II.

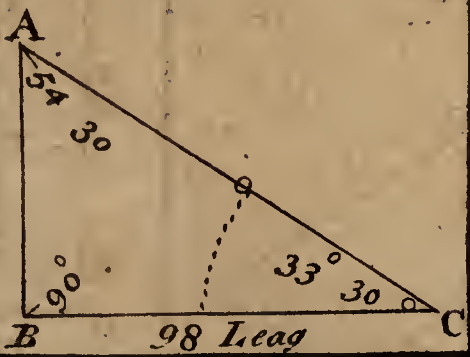


Fig. III.

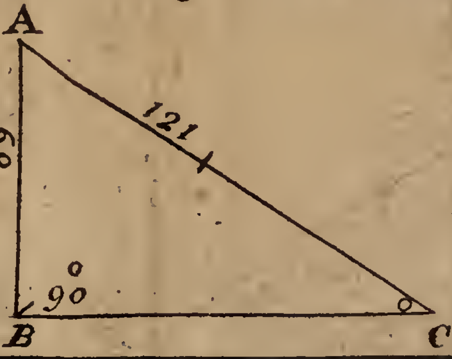


Fig. IIII.

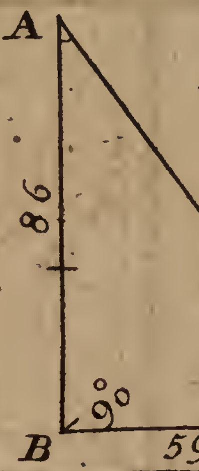


Fig V.

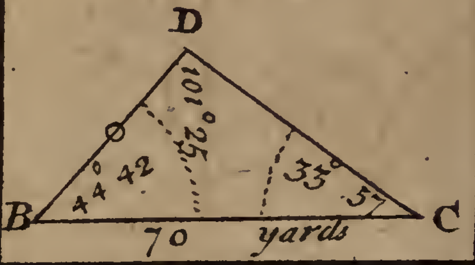


Fig. VI.

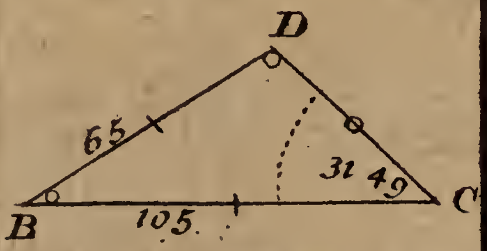


Fig. VII.

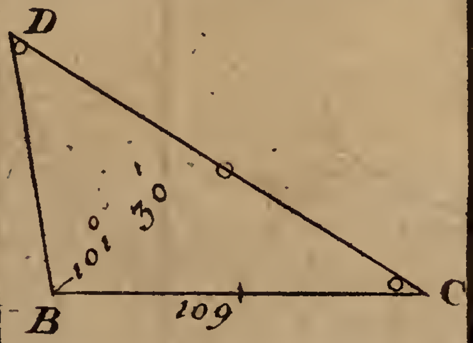


Fig. VIII.

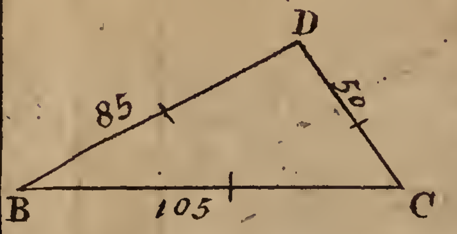


Fig. IX.

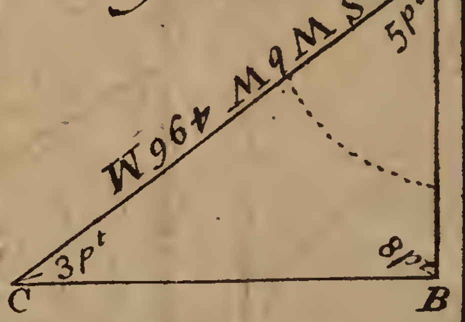
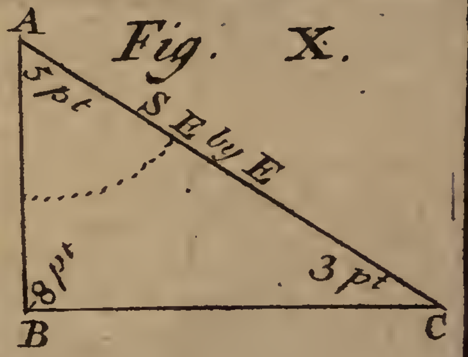


Fig. X.



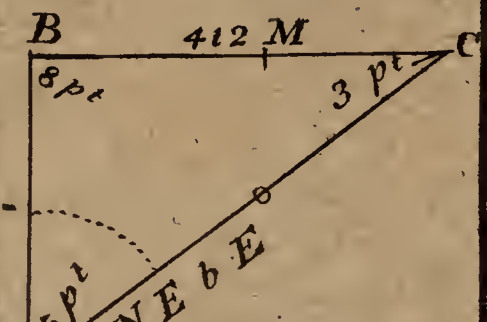


Fig XI

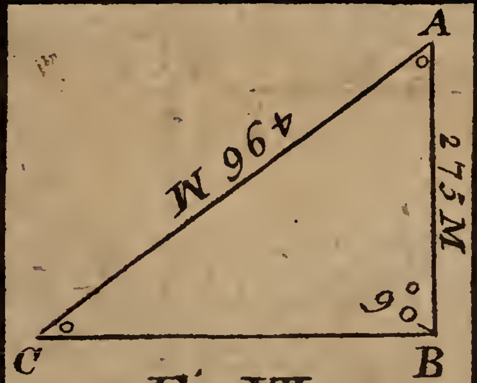


Fig XII

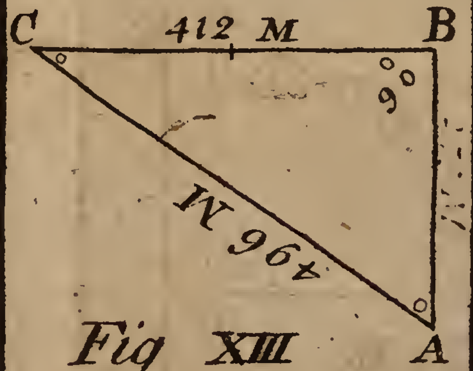


Fig XIII

Fig XIIII

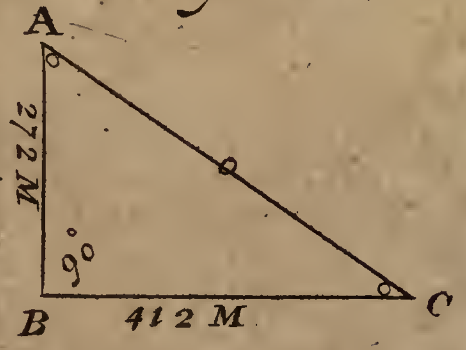


Fig I for 1st axi.

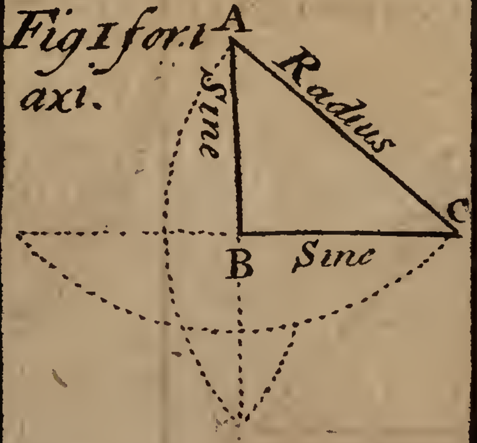


Fig & II for 1st Axi:

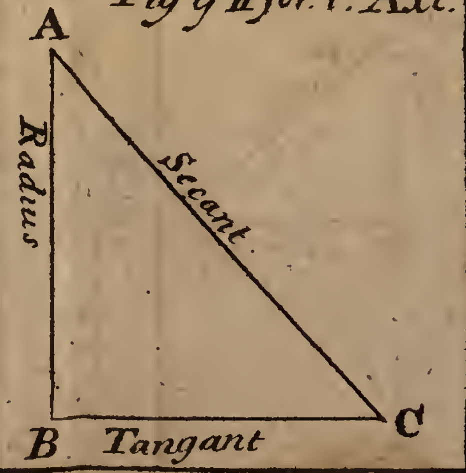
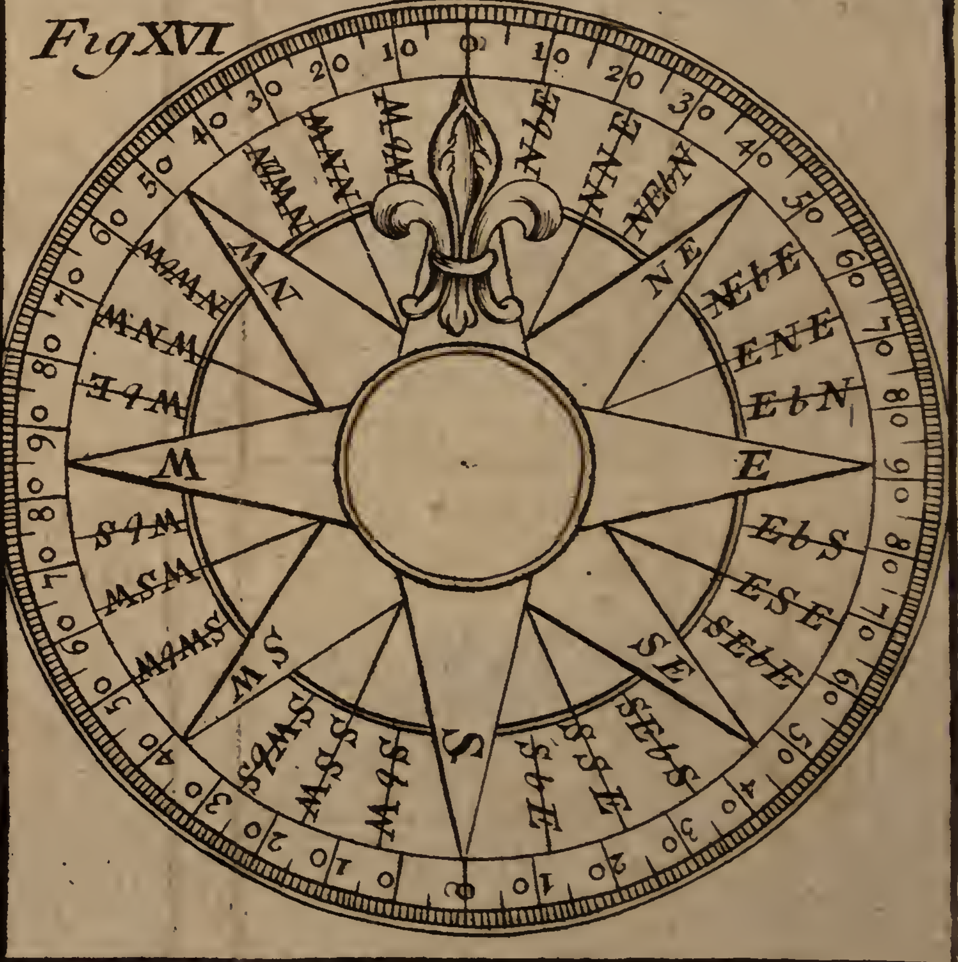


Fig XVI



by ſomething faſtened to it at every 50 Feet diſtance for a Knot. Now the *Log-line* being wound on a *Reel*, and the *Log* put into the Sea ; if the *Log-line* be veered out ſo faſt as the Ship ſails, then look how many Knots are veered out in Half a Minute's time ; juſt ſo many Miles or Minutes doth the Ship run in one Hour.

5. One of theſe Miles contain 6000 Feet , and is greater than a *Statute* or *common Mile*, that being but 5000 Feet ; of which about $69\frac{1}{2}$ (on the Meridian or any great Circle, is a Degree ; but in the Practice of *Navigation*, 60 Miles or Minutes are counted for a Degree, therefore I call them Minutes.

6. *In the Steerage*, or ſome other convenient Place of the Ship, hangeth a *Table* called the *Log-Board*, divided into 5 Columns ; wherein are writtten the *Hours of the Day*, *Courſes Steered*, *Knots* &c. veered out ; and laſtly, the *Winds* ; as in the Table following.

The Form of the Log-Board.

Hours of the Day,	*Courſes or Points*	*Knots*	*Fathoms of 5 Feet.*	*Winds.*
H.	C.	K.	F.	W
2	S W by S.	7	5	W N W
4		7	5	W by N
6	S	8		W S W.
8		8	5	
10	N W by N $\frac{1}{2}$ W.	4	8	W by S.
12		5	4	
2		5	6	
4	S W	7		W N W
6		8		
8	S E	4	4	S W by S.
10	S W.	4	5	S S E.
12	E S E.	5	3	S.

Note, The Column for Courſes is made ſometimes juſt before the Column for the Winds, and then the three narrow Columns ſtand together.

7. The Day begins and ends at Noon; that is, from Noon to Noon is the Length of the Day.

8. Every Day at Noon the *Log-board* ought to be Copied into a *Log-book*, ruled like the *Log-board*: Then muſt be caſt up how much the Ship hath ſailed on each Courſe.

9. If the Ship ſails by a Wind, it's uſual to allow one Point for Leeward-way; ſo that when the Ship is cloſe haled, and doth lie $5\frac{1}{2}$ Points from the Wind, yet her Courſe corrected is $6\frac{1}{2}$ Points from the Wind.

10. The ſeveral Courſes (being corrected) and Diſtances, are to be brought into one Courſe and Diſtance; which is called *Reſolving a Traverſe*, and to lay it down by Scale and Compaſſes, take the four following Rules, which give the Points that are between each Courſe, called the Angle between both Courſes.

Rule 1. Two Meridians, and two Parallels; the leſſer Courſe ſubtracted from the greater, gives the Angle between both Courſes.

Rule 2. Two Meridians and one Parallel; add both Courſes together.

Rule 3. One Meridian, and two Parallels; ſubtract the Sum of both Courſes from 16 points.

Rule 4. One Meridian, and one Parallel; add 8 Points, the leſſer Courſe, and the Complement of the greater together; the Sum is the ſaid Angle.

Note 1. North and South are called Meridians, and Eaſt and Weſt are called Parallels.

2. By Complement of the greater Courſe, underſtand how much it wants of 8 points.

3. To know the Meridians, and Parallels, the Firſt and Second Courſes are compared together, and the ſecond and third, and the third and fourth, &c.

Example. *A Ship being bound to a certain Port, meeting with contrary Winds, ſails firſt SE by S. 67 Minutes; then S. E by E. 53; then WSW. 45; then N E by N. 74; then Weſt 57; and then S. by E. 83 Minutes: I demand the Difference of Latitude, Departure from the Meridian, and direct Courſe, and Diſtance from the firſt Place departed?* Plate 2. Fig. 15.

1. Set down the ſeveral Courſes and Diſtances, with the points from the Meridian, *&c*, as in the following Table.

Number.	*Courſes.*	*Diſt in Min.*	*Points from the Meridian*	*Points for Laying down*	*Diff. Latitude in Minutes.*		*Departure. in Minutes.*	
					North	South	Eaſt	Weſt
1	S E by S.	67	3	3		55.7	37.2	
2	S E. by E.	53	5	14		29.4	44 1	
3	W S W.	45	6	5		17.2		41.6
4	NE by N.	74	3	3	61.5		41.1	
5	Weſt	57	8	5				57.0
6	S by E.	83	1	7		81.4	16 2	
	Sum'd up				61 5	183.7	138.6	98 6
	Subtract					61.5	98.6	
	Difference of Latitude					122.2	40.0	Depart.

2. In the fifth Column put the points for laying down; which are found by the Four Rules foregoing: For the Firſt Courſe always is the ſame with the *Points* from the Meridian; for the ſecond Courſe it's 14 *Points*, found by comparing the Firſt and ſecond Courſes together, in which are one Meridian and one Parallel; and by the 4*th Rule* it makes 14 *Points* for laying down: Again, comparing the ſecond and third Courſes it's one Meridian and two Parallels, which by the *Third Rule* makes 5 *Points* for laying down: Again, the Third and Fourth Courſe compared, it's one Meridian and two Parallels; which, by the Firſt *Rule* makes 3 Points for laying down; and ſo for the reſt, as in the foregoing Table.

3. By theſe Points for laying down, it's eaſy to delineate the Traverſe; as you ſee in *Plate* 2. *Fig.* 15. which is thus.

Firſt, Draw the Meridian AB, and on A draw an Arch, with the Chord of 60 degrees, on which Arch lay 3 Points; by it draw a S E by S. Line, laying thereon (from A) 67 Minutes, the Diſtance Run S E by S.

Secondly, With a *Chord* of 60 *Degrees*, and one Foot at the end of the SE by S. Line, draw an Arch, on which lay 14 Points: That is, take 7 *Rumbs* from the *Scale of Rumbs*, and lay it twice on the ſaid Arch; by it and the end of the S E by S. Line, draw a S. E. by E. Line, making it 53 Minutes long, ſo the ſecond Courſe is finiſhed.

Thirdly, At the end of the S E by E. Line, in like manner with the Chord of 60 Degrees, draw an Arch, and thereon lay 5 Points, by which and the End of the S. E. by E. Line draw the WSW. Line 45 Minutes long.

Fourthly, After the ſame manner draw the NE. by N. Line 74 Minutes long: Then the Weſt Line 57 Minutes long. And then the S. by E Line 83 Minutes long, ending in C, the place where the Ship now is.

Laſtly, Draw a Line from C to A (the place the Ship departed from) and from C let fall the Perpendicular BC; then is AC the Ship's Diſtance from the place of departing, AB her Difference of Latitude, and BC her Departure from her firſt Meridian, each being meaſured on the ſame *Scale* the other Lines were taken from, will ſhew how much they are ſeverally, and the Angle BAC meaſured on the *Scale of Chords* or *Rumbs*, ſhews her Courſe.

4. Then by *Problem* 1. *Section* 3. of this *Chap.* find the Difference of Latitude and Departure from the Meridian; for thoſe Courſes and Diſtances ſeverally; that is, by the *Firſt Caſe of Plain Sailing*, having the Courſe and Diſtance Run given; to find the Difference of Latitude, and the Departure from the Meridian; and that for each given Courſe; which place in their proper Columns, thus: If the Courſe be North Eaſterly put the Difference of Latitude in the North Column under (*North*;) and the Departure in the Eaſt Column under (*Eaſt*:) If the Courſe be South Eaſterly, then put the Difference of Latitude in the South Column, and the Departure in the Eaſt Columns; if South Weſterly, then in the South and Weſt Column; and if North Weſterly, then in the North and Weſt Columns.

As for Example. The *Firſt* Courſe in the foregoing *Traverſe* is S. E. by S. that is, South Eaſterly; the Difference of Latitude Minutes 55.7, place in the South Column; and the Departure Minutes 37.2 put in the Eaſt Column; as in the Table foregoing. The like obſerve for all the reſt.

Note, When the Courſe is E. W. N. or S. the Diſtance ſail'd, then place in the Eaſt, Weſt, North or South Columns; as here the *Fifth* Courſe is W. the Diſtance 57 Minutes is placed in the Weſt Column, as you ſee above in the *Table*.

5. Having found the Difference of Latitude, and Departure from the Meridian for each *Courſe*, and placed them in their proper Columns; add up the *North*, *South*, *Eaſt*, and *Weſt* Columns, and ſubtract the *North* and *South* Columns, the one from the other, that is, the leaſt from the greateſt, for the Difference of Latitude; in like manner, the *Eaſt* and *Weſt* Columns for the Departure: As in the foregoing Table, the Sum of the *North Column* 61.7 ſubtract from the Sum of the *South Column* 183.7, the Remainder 122.2 is the Difference of Latitude *Southerly*: And the Sum of the *Weſt Column* 98.6, ſubtracted from the Sum of the *Eaſt Column* 138·7, the Remainder 40·1, is the Departure from the Meridian Eaſterly.

6. Then having found the Difference of Latitude, and Departure from the Meridian, the Courſe and Diſtance may be found by *Problem* 6. *Section* 3. of this *Chap.* And in this Example the Difference of Latitude being Minutes 122.2 *Southerly*, and the Departure Minutes 40.1 *Eaſterly*, the Courſe will be South 18d. 10m. Eaſterly; that is, S by E. ¾ E. almoſt, and the Diſtance Minutes 128,7 which was required.

After this manner may you work any *Traverſe*; and for the Learner's Practice, I ſubjoin the following Examples.

Example 2. *Suppoſe in* 24 *Hours a Ship ſaileth as followeth, SW. by S.* 30 *Minutes, S.* 33, *NNW. ½ W.* 32, *S W.* 39, *S E.* 9, *and E S E.* 11 *Minutes: What is her Difference of Latitude, Departure from the Meridian, direct Courſe and Diſtance?*

Anſw. Difference of Latitude Minutes 67·9 Southerly, Departure Minutes 42.8 Weſterly, Courſe is South 32d. 15m. Weſterly, or SW. by S neareſt, Diſtance Minutes 80·3 Tenths.

Example 3. *If a Ship ſaileth by the Log-Board in* 24 *Hours as follows,* N N E. 83 *Min.* S W 74, E *by* S. 92, N N W. 126, S *by* W. 47, *and* NE *by* N. 78 *Minutes: What is her Difference of Latitude, Departure, direct Courſe, and Diſtance Run?*

Anſw. Difference of Latitude Minutes 141.6 Northerly, Departure 55.6, Eaſterly, Courſe is North 21d. 25m Eaſterly, or NNE. neareſt, Diſtance Minutes 152·5.

Example 4. *If a Ship ſaileth* W *by* S. 87 *Min.* N. 46, SSE. 75, E. 83, NW *by* W. 79, NE *by* E. 57, *and* NW *by* N. 64 Min. *I demand her Difference of Latitude, Departure, direct Courſe, and Diſtance Run?*

Anſw. The Difference of Latitude Minutes 88.6 Northerly, Departure Minutes 27.5 Weſterly, Courſe is North 17d. 15m. Weſterly, or N. by W. ½ W. neareſt, Diſtance 93 Minutes.

Example 5. *A Ship ſaileth as follows, N. N.E.* 55 *min. N W.* ¼*W.* 96, *S by E* ¼ *E.* 57, *W S W.* ½ *W.* 89. *N E by N.* ¾ *E.* 100, *SW by W.* ½*W.* 54. *and N by E,* 50*m. What is her Difference of Latitude, Departure, Direct Courſe, and Diſtance Run ?*

Anſw. Difference of Latitude min. 131.8 Northerly, Departure minutes 92.1 Weſterly, Courſe 34d.56m. North Weſterly, or NW by N. neareſt, and Diſtance 161 Minutes.

Example 6. *A Ship in* 46*d.* 24*m. South Latitude, ſaileth by the Log-board in* 24 *Hours S E.* 8 *min. S W by W.* ½ *W.* 6. *N E by E* 5. *W N W* ½ *W.* 9, *N W.* 4. *E S E.* ¼ *E.* 3, *S. by E.* 7, *N N. E.* ½ *E.* 4, *and E* 7 *min. What is her Difference of Latitude, Departure, direct Courſe, Diſtance Run, and Latitude ſhe is in ?*

Anſw. Difference of Latitude min. 4.62 Southerly. Departure min. 6.17 Eaſterly, Courſe is South 53d.10m. Eaſterly or SE. ¾ E. Diſtance Run min. 7.71., and Latitude 46d. 29m. South

Example. 7. *Admit a Ship in* 1*d.* 30*m. North Latitude, ſails N N E* 6 *min. S E by S.* ½ *E.* 5, *N E by E* ½ *E.* 4. *W N W.* ¾ *W.* 8, *S W by S.* ½ *W.* 7. *N W by* N. 4, *E N E* 5. *S W.* 7. *and SE by E* 5 *min. I demand her Difference of Latitude, Departure, direct Courſe, Diſtance Run, and what Latitude ſhe is in ?*

Anſw. Difference of Latitude minutes 2.40 Southerly, Departure min. 1.59 Weſterly, Courſe is South 33d. 31m, W.erly, or S W by S. Diſtance minutes 2.88 and Latitude ſhe is in 1d. 28m North ?

Thus much for the *Second Part of Plain Sailing*, called a *Traverſe* we go on to the Uſe of an *Oblique Triangle* in *Plain Sailing*

Sect V. *Plain Sailing the Third Part, or the Doctrine of Oblique Angles applied in Problems of Sailing by the* Plain Chart.

Altho' this Part of Plain Sailing is the leaſt uſeful, and moſt difficult ; yet for the Learner's Diverſion I will add ſome *Problems.*

Problem 1. *Suppoſe two Ports lie North and South, and a Ship ſails from the Northermoſt SE.* 68 *Minutes ; another from the Southermoſt ſails NE by N. till ſhe meet the firſt Ship : I demand the Diſtance of theſe Ports, and the Second Ships Diſtance Run ?*

In the Oblique Triangle ADE, *Plate* 3. *Fig.* 1.

Let A repreſent the Northermoſt } *Port*
D the Southermoſt——— ——— }

Side { AE the firſt——— } Ship's Courſe and Diſtance
DE the ſecond——— }

E the Place where the Ships meet.

Here are two Angles and one Side given, and therefore by *Chap.* 2. *Sect.* 3. *Prob.* 5. *Caſe* 1: *of Oblique-angles.* 1.

1. For the Side *AD* the Diſtance of the two Ports, the Proportion is,

S. *ADE* .. Side *AE* : : S. *AED* .. Side *AD*.

S. 3 *Points* ·· 68 Min.: ; S. 9 Points .. Min. 120.5 Tenths.

Note; When an Angle exceeds 8 Points ſubtract it from 16; as here, 9 Points being ſubtracted from 16, the Remainder 7 Points, is to be uſed inſtead of it.

2. For the Side *DE* the ſecond's Ships Diſtance, the Proportion is;

S. ADE .. Side AE : : S. DAE .. Side DE.

S. 3 points ·· 68 Min. : : S. 4 Points .. Min 86.2 Tenths.

Problem 2. *Suppoſe two Ports lie* N E. *and* S W. *and a Ship ſails from the Southermoſt* ESE. 45 *minutes, another from the Northermoſt runs* 72 *Minutes, and then meets the firſt Ship; I demand the Courſe ſteer'd by the laſt, and the Diſtance of the Ports.*

In the Oblique Triangle ADE, *Plate* 3. *Fig.* 2.

Let A repreſent the Southermoſt } Port.
D the Northermoſt —— —— }

Side { AE the firſt —— } Ship's Courſe and Diſtance.
Side { DE the ſecond }

E the Place where the Ships meet.

Here are two Sides and one Angle oppoſite given; and by *Chap.* 2. *Sect.* 3. *Prob.* 6. *Caſe* 2 and 3. of *Oblique-angles.*

1. For the Angle ADE the ſecond Ship's Courſe, the Proportion is,

Side DE .. S. DAE : : Side AE .. S. ADE.

72 Min. .. S 67d. 30m.: : 45 Min. .. S. 35d. 15m. which ſubtract from S W. 45d. makes the Courſe 9d. 45m. South Weſterly, or S $\frac{3}{4}$ W.

2. For the Side AD the Diſtance of the two Ports, the Proportion is,

S. DAE .. Side DE : : S. AED .. Side AD.

S. 67d. 30m. ·· 72 Min. : : S. 77d. 15m. ·· 76 Min. the Diſt.

Problem 3. *Two Ships ſail from a certain Road, one ſails* S S E. 50 *Minutes, the other* SSW. 35 *Minutes. I demand their Bearing and Diſtance?*

In the Oblique Triangle ADE. *Plate* 3. *Fig.* 3.

Let A repreſent the Road.

Side { AD the firſt —— } Ship's Courſe and Diſtance.
Side { AE the ſecond -- }
Side { DE the Bearing and Diſtance of the two Ships.

Here are two Sides and one Angle between them given; and by *Chap* 2 *Sect* 3. *Prob.* 7. *Caſe* 4 and 5 of *Oblique-angles.*

1. For the Angles ADE and AED; their Bearing.

Side { AD 50 *Min* | From the three Angles ——— 180d. 00m.
Side { AE 35 *Min.* | Subtract the Angle DAE ——— 45d. 00m.
Sum Sides 85 *Min.* | Sum of ADE and AED ——— 135d. 00m.
Diff Sides 15 *Min.* | The half Sum ADE and AED —67. 30m.

Sum Sides .. *Diff. Sides* : : T. ½ *Sum Angles* .. T. ½ *Diff. Angles.*
85 *Minutes* .. 15 *Min.* : : T. 67d. 30m. .. T. 23d. 05m.
The half Diff. of the Angles 23d. 05m.
Added, is the greater Angle 90d 25m AED.
Subtracted, is the leſſer Ang. 44d. 25m. ADE;

which added to SbE, 22d. 30m. is South Eaſterly 66d. 55m. and North Weſterly 66d. 55m. that is E S E. and W N W. neareſt, is the Bearing of the two Ships.

2 For the Side DE their Diſtance, the Proportion is;
S. ADE .. *Side* AE : : S. D A E .. *Side* DE required.
S. 44d. 25m. .. 35 *Min.* : : S. 45d. 00m. .. *Min.* 35:4 Tenths.

Problem 4. *Suppoſe a Ship ſail* NE. 50 *Leagues, then South Eaſterly* 85 *Leagues; and then forced back by foul Weather* 105 *Leag. to the Place from whence ſhe firſt ſailed: I demand her ſecond Courſe, and her laſt Courſe back?*

In the Oblique Triangle ADE, *Plate* 3. *Fig.* 4.
Let A repreſent the Place ſailed from at firſt.
D } the { ſecond Place, and DE ſecond Courſe and Diſt.
E } the { third Place, and EA third Courſe and Diſtance.

Here are three Sides given; and by *Chap.* 2. *Sect.* 3. *Prob.* 8. *Caſe* 6. of *Obliquangles*, the Proportions are;

1. For FE the Difference of the Segments AB and BE; the Operation is,

Leagues
Side { DE 85 | *Side* AE .. *Sum* DE&DA : : *dif.* DE&DA .. FE *dif. Seg*
Side { DA 50 | 105 *leag.* .. 135 *Leagues* : : 35 *Leagues* .. 45 *Leag.*
Sum — 135 | 45 FE Difference of the Segments AB, and BE
Diff. —— 35 | 105 } the half is { 75 BE the greater Segment
60 } the half is { 30 AB the leſſer Segment.

2. For the Angles DAE and AED, the Proportions are; Hypotenuſe AD .. Radius : : Leg AB .. Sc. DAB or DAE.

50 Leagues .. S. 90d. : : 30 Leag. .. S. 36d. 53m.
Subtract from ——— ——— 90d. 00m.
Reſteth Angle DAE ——— 53d. 07m. which

being added to N E. makes North E.erly 98d. 07m. or South Eaſterly 81d. 53m. ſo that the Courſe from E to A, is W. by N. $\frac{1}{4}$ W. back to the Place firſt ſailed from. And again; Hypotenuſe DE .. Radius : : Leg BE .. Sc BED or AED

85 Leagues .. S. 90d. : : 75 Leag. .. S. 61d. 55m.
Subtract from ——— ——— 90d. 00m.
Reſteth Angle AED ——— 28d. 05m.

Which ſubtract from the South Eaſterly 81d. 53m. leaveth 53d. 45m. or SE. $\frac{3}{4}$ E. neareſt for the ſecond Ships Courſe from D to E.

Theſe are the kinds of *Oblique Queſtions*, though Multitudes may be propoſed, of which here followeth a *Taſte*, to exerciſe the *Young Learner*; all of them to be reſolved by the foregoing.

Problem 5. *Suppoſe a Merchant-ſhip in* 45d. 30m. North Latitude, *falls into the Hands of Pyrates, who take away his Sea-Compaſs; after which he ſaileth as directly as he can* 67 *Leagues between the South and Weſt, and at the end of two Days meets a Ship of War, who alſo had been the Day before in* 45d. 30m. North Latitude, *and had ſailed thence S E. by S.* 39 *Leagues; now the Merchant-ſhip left thoſe Pyrates lying to and fro where they robbed him, and the Man of War being deſirous to find them; I demand what Courſe he muſt ſhape to ſpeak them?*

Anſw. North 61d. Eaſterly, or NE by E. half E.

For this *Problem* is an *Oblique Triangle, Two Sides and One Angle oppoſite* given; to find the Angle oppoſite to the other *Side*; which Triangle is thus made.

1. Deſcribe a Circle with the Chord of 60 Degrees, and quarter it, on whoſe Diameters ſet N. E. S. W. and A at the Center; but (always) N. at the upper part, and at E the Right hand of the Circle.

2. Then lay 3 Points from S towards E on the Circle, and draw the SE by S. Line, AD 39 Leagues long.

3. With 67 Leagues, and one Foot on D, with the other croſs the Line WAE (produced to the Eaſtward) in C, the place where the Ship fell in with thoſe Pyrates.

4. Then a Line being drawn from C to D it's done: For A and C are both in the Latitude of 45d. 30m. and AD repreſents the *Man of War's Courſe and Diſtance*, and CD the *Merchant-man's* after he loſt his Compaſs; ſo that the Angle ACD being meaſured on the *Scale of Chords*, will ſhew her Courſe from the Weſt towards the South, the oppoſite point is the Man of War's Courſe North Eaſterly, to find thoſe Pyrates.

Problem 6. *Coaſting along Shoar, I ſee two Capes of Land; the firſt (did by the Compaſs) bear* N. *the ſecond* WNW. *then I ſtood away* NW *by* N. 9 *Minutes, until the firſt beared from me* E *by* S. *and the ſecond* S *by* E. *the Bearing and Diſtaence of them is required.*

Anſw. South 38d. 05m. Weſterly or S. W. by S. ½ W. and N E. by N ½ E. neareſt, Diſtance is Minutes 6.22 Parts of a hundred.

Note, In all Queſtions of this Nature, you muſt, as preparative Work, find the Diſtance of each Cape from the Ship at firſt ſeeing them, or at laſt ſetting them; which is evident by the Projection, thus,

1. Having drawn a Circle, quarter'd it, and placed the Letters N, S, E, W, and A: as directed in the laſt *Prob.* produce AN up higher, becauſe the firſt Bearing is North..

2. Lay 6 Points from N. towards W, and draw the WNW. Line for the ſecond Cape's Bearing.

3. Lay 3 Points from N, towards W, and draw the N W. by N. Line 9 Minutes long, from A to D, the Ship's Courſe, and Diſtance.

4. Then lay 7 Points from S towards E, and laying a *Scale* on it and A, draw an E. by S. Line from D, parallel to the edge of the *Scale*, to cut the North line in B, the firſt Cape.

5. In like manner, lay 1 point from S towards E, and lay a *Scale* on it and A, draw a S by E. Line from D, parallel, to the Edge of the *Scale*, to cut the WNW. Line in C, the Second Cape.

6. Draw a Line from B to C, and it's done: For the Line BC repreſents the *Bearing and Diſtance of the two Capes* from each other, which being meaſured on the ſame *Scale* AD was taken from, will ſhew their Diſtance aſunder. And the

Angle A B C meaſured on any *Scale of Chords*, will ſhew their Bearing to be South Weſterly, and North Eaſterly.

But to find theſe Things by *Trigonometry*. it's neceſſary to find the Sides AB and AC; or elſe the Sides DB and DC; which is done in two Oblique Triangles ABD, and ACD, in each all the Angles, and one Side is given, to find a Side.

And Note, A repreſents the Place of the Ship at firſt ſeeing the *Capes*, and D the Place at laſt Setting them.

So that, when the Sides AB and AC, or DB and DC, are found; then is their either the Oblique Triangle ABC, or BDC to work in; then BC (the Side common to both Triangles) with its agreeing Angles may be found, by which their bearing and Diſtance from each other is diſcovered; And in each Triangle there is two Sides and one Angle between them given; to find the other Angles, and third Side; which is to be wrought as the third *Problem* of this *Section*.

Problem 7. *Suppoſe a Ship ſailing* NW. *two Iſlands appear in ſight, one bears* WNW. *the other* N. *from the Ship, and when the Ship hath ſailed 6 Minutes further, the firſt bears* W by S. *and the other* NE. *Their Bearing and Diſtance is required.*

Anſw. South 58d. 46m. Weſterly, or SW. by W. $\frac{1}{4}$ W. and N E. by E. $\frac{1}{4}$ E. Diſtance is Minutes 9.7 Tenths. Found out as before, in the laſt Problem.

Problem 8. *Three Ships ſail from one Port, the firſt ſails* S W. *by* W. *the ſecond* W *by* S. $\frac{1}{2}$ W. *and the third* NW *by* W. 8 *Minutes; then the firſt bears from the third* S *by* W. *the ſecond bears from the third* S S E. *The firſt and ſecond Ship's Diſtance ſailed, and their Bearing and Diſtance from each other is required.*

Anſw. Firſt Ship's Diſtance Minutes 10.45, ſecond's Diſtance Minutes 4.65, their Bearing North 37d. 14m. Eaſterly, or NE. by N. $\frac{1}{4}$ E. and SW by S $\frac{1}{4}$ W. Diſtance Minutes 6.75. This alſo is wrought by the Direction of the 6th Problem.

Problem 9. *Admit ſailing along Shoar I ſee two Head-lands, the Eaſtermoſt bears* N N E. *and the Weſtermoſt* N W *off me, at the ſame time an Iſland bears* S. *then after I ſailed* W 8 *Minutes the firſt did bear* N E *by* E. $\frac{1}{2}$ E *the ſecond* N N E. *and the Iſland* ESE *from me: The Bearing and Diſtance of theſe Places from each other are required?*

Anſw. The Head-lands bear North 88d. 53m. Weſterly or

Eaſt and W neareſt, Diſtance Minutes 7·95. The Eaſtermoſt *Headland* bears from the Iſland North 14d. 30m. Eaſt, or N by E. ¼ E. and S by W ¼ W. Diſtance Minutes 9.15, and the Weſtermoſt Headland bears from the Iſland North 32d. 15m. Weſt, or N W by N. and S E by S. Diſtance, Minutes 10.6 Tenths.

This is of the ſame Nature with the ſixth *Problem*, only here are three Things to be found as preparative, *viz.* the Diſtance of each Headland and the Iſland from the Ship, and conſequently in three Triangles both in the preparative, and ſubſequent Work, Proportions are made, which makes up Nine ſeveral Statings, to reſolve this *Problem.*

The next 4 *Problems* are uſed in turning to Windward.

Problem 10. *Suppoſe the Wind South, and a Ship is bound to a Port 400 Leagues directly to Windward, and makes her Way good within 6¾ of the Wind: I demand her Diſtance ſailed upon each Tack, to gain the ſaid Port?*

Anſw. 823 Leagues is the Ship's Diſtance ſail'd on each Tack. For it's thus projected by *Plain* the *Scale.*

1. Deſcribe a Circle with the Chord of 60 Degrees, quarter it and place N. S. E. W. and A, as directed in *Prob.* 5.

2. Lay 400 Leagues on the Meridian, from A (Southerly) to B, the Place the Ship is bound unto

3. From S lay 6¾ Points towards E, and by it from A, draw the ESE ¾ E. Line AC.

4. Alſo lay 6¾ Points from S towards W, and laying a *Scale* on it and A, draw a WSW ¾ W. Line from B, parallel to the edge of the *Scale*, to cut the E S E ¾ E. Line in C, the Place where the Ship Tackt, and it's done:

For A repreſents the Place the Ship ſails from, B the Port 400 Leagues directly to Windward, AC equal to CB, the *Ship's* Diſtance ſail'd on each Tack; which being meaſured on the ſame *Scale* AB was taken from, will ſhew how much it is.

But to work it by *Trigonometry*, in the Oblique Triangle ABC, all the Angles and one Side AB being given, the other Sides AC and CB are found as in the *Firſt Problem* of this *Section*: And becauſe two Angles are equal, the Sides oppoſite to them are alſo equal; therefore one Proportion finds AC and CB.

Problem 11. *The Wind S. W. and a Ship plying to Windward, (making one or many Boards) having run 900 Leagues; that is, 450 with the Larboard-Tack aboard, and 450 with her Starboard Tack aboard, it got 300 Leagues directly to Windward: I demand how near the Wind ſhe makes her Way?*

Anſw. 70d. 32m. or 6¼ Points from the Wind. Which is thus delineated by the *Plain Scale.*

1. A Circle being deſcrib'd, quarter'd, and letter'd, as hath been directed in the former *Problems*: then lay 4 Points, from S, towards W, and by it and A, draw a (S. W.) Line 300 Leagues long, from A to B.

2. With 450 Leagues (taken from the ſame *Scale* AB was taken from) and one Foot on A, make an Arch; alſo with the ſame, and one Foot on B, croſs the former Arch in C.

3 From C draw Lines to A and B, and it's done: For the *Angle* BAC equal to the *Angle* ABC meaſured on any *Scale of Chords*, ſheweth how near the Wind the *Ship* makes her Way

But by *Trigonometry*, thus; In the Triangle ABC all three Sides are given, to find the Angles, which may be done by the *Fourth Prob.* of this *Sect.* Otherwiſe thus; becauſe AC and BC are equal; wherefore let fall a Perpendicular from C to the S. W. Line AB, as AD; which cuts AB in the middle, making AD 150 Leagues equal to BD, and ſo reduce the Oblique Triangle ABC into two equal Right-Angled Triangles, AD and BDC: whoſe Sides and Angles in each Triangle are equal to one another; ſo that one Proportion ſerveth to anſwer the Queſtion.

For in the Right-Angled Triangle ACD, there is given the Hypotenuſe AC 450 Leagues, and Leg AD 150 Leagues; to find the Angle CAD which is equal to the Angle CBD (the *Ship*'s Courſe from the Wind) which is done by *Axiom* 1. of *Plain Trigonometry*, thus

Hypot. AC .. *Radius* :: *Leg* AD .. S. ACD=BCD
450 *Leag.* .. S. 90d. :: 150*Leag.* .. S. 19d 28m.
Which ſubtract from —— ——— 90d. 00m.

Remainder is the Angle CAD=ABC 70d. 32m. or 6 ¼pts. the Ship's Courſe from the Wind SW.

Prob.

Problem 12. *Admit a Ship bound to a Port that lieth* S W by S. 484 *Leagues Diſtance, the Wind* S *by* E. *and makes her way good within* 6¼ *Points, of the Wind I demand how far ſhe muſt ſail upon each Tack, to gain the Port?*

Anſw. 690 Leagues on her Larboard Tack, and 328 Leag. on her Starboard Tack. Thus demonſtrated by the *Plain Scale*

1. The Circle deſcrib'd, quarter'd, *&c.* as formerly, lay 1 Point from S towards E. and by it and A, draw a S by E. Line AB repreſenting the Wind.

2. From S towards W, lay 3 Points, and by it and A draw a S W by S Line 484 Leagues long, from A to C.

3. From the Wind (S by E.) lay 6¼ Points towards W, and by it and A draw a (S W by W. ¼ W.) Line AD.

4. Likewiſe lay 6¼ Points from the Wind (S by E) towards E, on it and A, lay a *Scale*; then from C draw a (E by S ¼ E.) Line to cut the Wind, (S by E.) Line in B, and the S W. by W ¼ W. Line in D, and it's done. For AD, and DC repreſents the Ship's Diſtance Sail'd on each Tack, which being meaſured on the ſame *Scale* AC was taken from, will ſhew how much the Diſtance Sail'd on each Tack is,

By *Trigonometry* it's thus: In the Oblique Triangle ACD, all the Angles and one Side is given; to find the other two Sides, which is done by the firſt *Prob. of this Section*, in *Page* 71.

As S. A D C .. Side A C : : S. A C D .. Side A D
S. 3½ Points .. 484 leag. : : S. 10¼ Points .. 690 Leagues is the Diſtance ſail'd on her Larboard Tack

As S. A D C .. Side A C : : Sine C A D .. Side C D.
S. 3½ Points .. 484 leag. : : S. 2¼ Points .. 328 Leagues, is the Diſtance ſail'd on the Starboard Tack.

Problem 13. *If two Ports lie* S W *by* S. *and* N E *by* N. *Diſtance* 484 *Minutes, the Wind* S *by* E. *and a Ship ſails from the Northermoſt Port cloſe upon a Wind* 695 *Minutes, with her Larboard-Tack aboard, and* 332 *with her Starboard Tack aboard, and then arrives at the Southermoſt Port. I demand how near the Wind ſhe makes her way good upon each Tack?*

Anſw. 70d. 30m, on one Tack, and 70d. 40m on t'other; which is 6¼ Points from the Wind; that is S W. by W. ¼ W. with her Larboard Tack, and E by S. ¼ E, with her Starboard Tack.

Thus done by the *Plain Scale.*

1. Deſcribe a Circle with a Chord of 60 Degrees, quarter it, *&c.* as formerly, then lay 3 Points from S towards W, and by it and A draw a S W by S Line 484 Minutes long, from A to B.

2. Lay 1 Point from S towards E, and by it and A draw the S by E. Line AC.

3. With 695 Minutes (taken from the ſame *Scale* AB was taken from) and one Foot on A make an Arch; alſo with 332 Minutes, and one Foot on B, croſs the former Arch in D.

4. From D draw Lines to A and B, and continue the Line BD, till it cuts the S by E. Line AC in C, and it's done: For the Angles DAC, and ACD meaſured on the *Scale of Chords or Rumbs*, will ſhew how near the Wind the Ship makes her Way good on each Tack.

By *Trigonometry*, it's thus: In the Oblique Triangle ABD, all the Sides are given, to find the Angles; that is, AD 695 Minutes, AB 484, and BD 332; to find the Angles BAD, and BDA; which is done by the *Fourth Prob. of this Sect.* in *Pages* 72 *and* 73.

The next *Problems* are concerning *Currents.*

Problem 14. *Suppoſe a Current ſets NNE. 7 Minutes in a certain time, and a Ship ſails S S W. (by the Log) 9 Minutes in the ſame time? What is her true Courſe and Diſtance?*

Anſw. SSW. is the Ship's true Courſe, and Diſtance 2 Minutes: Which is evident by the *Plain Scale*, thus;

1. Having done as formerly as directed, in making a Circle, *&c.* Lay 2 Points from S towards W, and by it and A draw a SSW. Line 9 Minutes long, from A to B.

2. With 7 Minutes (taken from the ſame *Scale* AB was taken from) and one Foot on B, croſs the Line AB in C, ſo that BC may be NNE. and it's done: For AC meaſured on the ſame *Scale*, ſheweth the Ship's true Diſtance, Or thus,

From the Ship's ſuppoſed Diſtance SSW. 9 Min. AB
Subtract the Current's Motion NNE. 7 Min. BC
Remains the Ship's true Diſtance SSW. 2 Min. AC

The like is done for the two next following Problems.

Problem 15. *If a* Current *ſet* E. 4 *Min. an Hour, a Ship ſails* E. (*by the* Log) 5 *Minutes in an Hour: The Ship's true Courſe and Diſtance is required.*

Anſw The Ship's true Courſe is Eaſt, Diſtance 9 Minutes.

Prob. 16. *A Current ſetting* W S W. 90 *Minutes in a known time, and a Ship ſailing* E N E. *(by the Log)* 60 *Minutes in the ſame time: What is her true Courſe and Diſtance?*

Anſw. W S W 30 Minutns; ſo that ſhe is fallen a Stern.

Prob. 17. *Suppoſe a Current ſetetth* E. 2 *Minutes an Hour, and a Ship ſails* S. 6 *Minutes an Hour: What's her true Courſe and Diſtance?*

Anſw. South 18d. 26m. Eaſterly, or S by E. $\frac{3}{4}$ E. is the Ship's true Courſe, Diſtance min $\frac{3}{10}$.

By the *Plain-Scale* it's thus demonſtrated.

1. After a Circle is deſcribed, *&c.* as formerly, then lay 6 Minutes on the Meridian from A to B.

2. Draw BC parallel to WAE, and thereon lay 2 Minutes from B (towards the Right-hand) to C.

3. Then draw a Line from A to C, and it's done; for the Angle BAC is the *Ship's true Courſe*, and AC her true *Diſtance.*

By *Trigonometry* it's thus; the Triangle ABC is a Right-angled Triangle, in which both Legs are given, to wit, AB 6 Minutes, the Ship's ſuppoſed Diſtance, and BC 2 Minutes, the Current's Motion, to find the Angle BAC her true Courſe, and AC her true Diſtance; which is done by *Axiom the Firſt of Plain Trigonometry.*

In like manner, *Problem* 18 and 19 is performed.

Problem 18. *If a Ship ſails (five Days together) by the Log,* S.W. 725 *Minutes: In a Current that ſetteth (in the ſame time)* S. E. 280 *Minutes: What's the true Courſe and Diſtance?*

Anſw. South 23d. 52m. Weſterly, or S S W. is the Ship's true Courſe, Diſtance 775 Min.

Problem 19. *Admit a Ship ſails* W. 730 *Minutes thwart a Current ſetting to the Southward; and then by Obſervation findeth the Difference of Latitude is* 4d. *or* 240 *Minutes. I demand her true Courſe and Diſtance.*

Anſw. South 71d. 48m. Weſterly, or W S W. $\frac{1}{4}$ W. is the Ships true Courſe, Diſtance 768 Minutes.

Problem 20. *If a Ship ſails* S. *by* E. 36 *Minutes in a Current, and then arrived at a Port which lieth from the Place ſhe departed from* S. E. *by* S. *Diſtance* 54 *Minutes: I demand the Current's Motion both in Quality, and Quantity; that is, how it ſetteth and how faſt.*

Anſw. Current ſetteth South 67d. 20m. Eaſt, or E. S. E is the Drift of the Current as to Quality and Minutes, 24.9 Tenths is its Drift as to Quantity. By the *Plain Scale*, thus,

1. As before, having deſcribed a Circle, *&c.* Lay 1 Point from S. towards E, and by it and A, draw a S. by E. Line 36 Minutes long, from A to B:

2. Lay 3 Points from S. towards E. and by it and A, draw a S. E. by S. Line, 54 Minutes long from A to C.

3. Then draw a Line from B to C, and it's done: For the Angle A C B meaſured (on the Scale, ſheweth the Current's Motion as to its Quality, which way from the S. E. by S. and the Side BC meaſured (on the Scale) ſheweth the Current's Motion, as to its Quantity, how much, or how faſt.

But by Trigonometry, it's thus,

In the Oblique Triangle A B C, there is given, two Sides and an included Angle; that is, the Side AB 36 Minutes, the Side AC 54 Minutes, and the Angle BAC two Points or 22d. 30m. to find the Angles ABC, ACB and the Side BC; which is done by the third Problem of this Section.

Problem 21. *Suppoſe a Ship ſails from a certain Cape, or Headland and (by the* Log) *in* 24 *Hours, runneth* S S W. 49 *Minutes in a Current ſetting between the* N. *and the* W. *and then the Cape did bear* E N. E. *and by Obſervation, the Ship's Difference of Latitude was* 30 *Minutes, I demand the Current's Motion; that is, upon what Point of the Compaſs, and how faſt?*

Anſwer. The Current ſets North 74d. 07m. Weſt, or WN W. ½ W. neareſt, and at the Rate of Minutes 2.32 an Hour. Thus demonſtrated by the *Plain Scale.*

1. After the Circle is deſcribed, quartered, *&c.* lay two Points from S towards W, and by it and A, draw a S. S. W. Line 49 Minutes long, from A to B.

2. Lay ſix Points from S towards W, and by it and A draw a W. S. W. and E. N. E. Line AC.

3. Lay 30 Minutes on the Meridian AS from A to D, and from D draw a Weſt Line parallel to AW, to cut the WSW Line in C.

4. Then draw a Line from B to C, and it's done: For the Angle ABC being meaſured on the Scale, ſheweth the Current's Motion from S.S. W. and the Side BC being meaſured ſheweth how faſt.

By *Trigonometry* it's thus;

1. In the Right Angle Triangle ADC, there is given, the Leg AD 30 Minutes, Angle DAC 6 Points, and Angle ACD 2 Points; to find the Hypotenuſe AC, which is done by *Axiom Firſt of Plain Trigonometry*

2. Then in the Oblique Triangle A B C, there is given, the Side AB 49 Minutes, the Side AC found before, and the included Angle B A C 4 Points or 45d. to find the Angle A B C, (the Current's Motion from S. S. W.) and the Side BC, it's Motion how faſt.

Let this ſuffice, for (tho' many more Problems might be invented in) the *Firſt Part of Navigation*, commonly called *Plain-Sailing*: *Mercator*'s-*Sailing* is next in order.

CHAP. IV.

The Second Part of Navigation, *or the Doctrine of* Plain Right Angle-Triangles, *applied in Problems of* MERCATOR'S-SAILING.

I Count it neceſſary to deſcribe *Mercator's-Chart*, and ſhew the Uſes of it, before the Problems of Sailing by it, which by this Method will the eaſier be underſtood.

Sect. I. *The Deſcription and Uſe of* Mercator's-Chart.

THIS *Projection* ſuppoſeth the Earth and Sea to make one round *Body* or *Globe*, in order to the right underſtanding of it, obſerve the following Definitions.

1. Upon this Earthly Globe is imagined two opoſite Points, one called the North Pole, the other the South Pole; as P, and I. *Plate* 5. *Fig.* 1.

2. In the middle between thoſe two Poles, or equally diſtant from each, is drawn a Line round the Globe, called the

Equator, from which Latitude taketh its beginning, and in which Longitude is reckoned; as ÆAQ.

3. Any Circle drawn through both Poles, is called a Meridian, as PMI, PNI, *&c.* anſwerable thereunto is any North or South Line drawn in the Chart.

4. Thoſe Circles which are parallel to the Equator, are called Parallels of Latitude; as *a l t*, *z l t*, *&c.* and are repreſented in the Chart by the Eaſt and Weſt Lines.

5. *Latitude* of a Place is the (neareſt) Diſtance of any Parallel paſſing over it from the Equator; from thence counted both ways to each Pole, ending in 90 Degrees the greateſt Latitude.

6. *North Latitude*, is on that Side the Equator towards the North Pole, and South Latitude on the other Side of the Equator, towards the South Pole.

7. *Difference of Latitude*, is the (neareſt) diſtance between any two Parallels, and ſheweth how far one Place is to the Northward or Southward of another; it never exceeds 180 Degrees.

8. *Longitude*, is reckon'd in the Equator, round which (by ſome) it's counted encreaſing to the Eaſtward till it end (where it firſt began) in 360 Degrees the greateſt Longitude: Others (as Mr. *Wakely*, in his *Mariner's Compaſs Rectified*) reckon it from one Meridian both Eaſterly and Weſterly, till both Accounts meet at 180 Degrees in the oppoſite Meridian, as the aforeſaid Book begins Longitude at the Meridian of *London*, and from thence counting Eaſterly, Eaſt Longitude 180 Degrees, and Weſterly, Weſt Longitude 180 Degrees, at which both Longitudes end.

9. *Difference of Longitude*, is that Diſtance or Portion of the Equator contained between the Meridians of any two Places, and ſheweth (in the Equator) how far the Meridian of one Place is to the Eaſtward or Weſtward of the Meridian of another, and never exceeds 180 Degrees.

From theſe Definitions, or Principles, there muſt neceſſarily follow theſe *Theorems*.

1. *The Diſtance of any two Meridians*, in any Parallel of Latitude, is leſſer than their Diſtance in the Equator.

2. The Degrees of Longitude deminiſh towards each Pole; and the nearer the Pole, the leſſer they are.

3. The Degrees of Latitude are equal in all Places or Parts of the Globe.

4. The *Plain Chart*, which counteth the Degrees as well of Longitude, as of Latitude in all Places to be Equal, is notoriouly Falſe.

5. Mr. *Wright*'s *Projection* (commonly known by the Name of *Mercator's Chart*) wherein, though the Degrees of Longitude are equal, having the Meridians Parallel to one another; the Degrees of Latitude are inlarged towards each Pole, in the ſame Proportion as the Degrees of Longitude diminiſh on the Globe, which will in all reſpects agree with the Globe, and is a true way of Sailing, let ſome ſay what they will to the contrary.

Theſe *Definitions* and *Theorems* duly conſider'd, there needs no more for the Deſcription of this *Chart*, it having only this Difference from the *Plain Chart*, before deſcribed in *Chapter* 3. *Section* 2, *Page* 53. that the Equator is divided and numbred in Degrees, as the graduated Meridian is; and without any further Deſcription, the Uſes are as follow.

Problem 1. *To find the Latitude of any Place in the Chart.*

This was taught before in the Uſe of the *Plain Chart*, in *page* 54, and needs no further *Rule* or *Example*.

Problem 2. *To find the Longitude of any Place in the* Chart.

The Rule 1. Take the neareſt Diſtance from the propoſed Place to any Meridian.

2. Move the Compaſſes (being kept at that Diſtance) with one foot on the Meridian, till both feet come to the Equator, and the Foot which ſtood on the propoſed Place ſheweth its Longitude required.

Example. I demand the Longitude of the *Lizard* in *England*?

Anſwer. 9d. 40m according to the old Way of computing the Longitude from the Meridian of *Pico Teneriff*: But 5d. 24m. Weſt Longitude, counting Eaſt and Weſt Longitude from the Meridian of *London*, according to the *Mariners Compaſs Rectified*.

Note, Some Charts begins Longitude at the *Lizard* counting from thence Eaſtward and Weſtward:

Problem 3, *To find the Courſe or Bearing of any two Places in the Chart.*

This is done as before in the Uſe of the *Plain Chart*, in *Page* 55, and needs no *Example.*

Problem 4. *To find the Diſtance of any two Places in the* Chart.

In this *Problem* are four Caſes; the two Places may be ſituated under one Meridian, under the Equator, or in one Parallel, or they may differ both in Latitude and Longitude.

Caſe 1. *Two Places under one Meridian, (that is, they differ only in Latitude) being given to find their Diſtance.*

The Rule. Find the Difference of Latitude between the two given Places, and it's the Diſtance required.

How to find the Difference of Latitude between the two Places, has been taught in *Chapter* 3. *Section* 3, *of Plain Sailing*, in *Page* 58.

Caſe 2. *Two Places in the Equator given; to find their Diſtance.*

The Rule. Find the Difference of Longitude between them, and it's the Diſtance required.

How to find the Difference of Longitude, will be ſhewed in the next *Section*, in *Page* 89.

Caſe 3 *Two Places in one Parallel (that is, they differ only in Longitude) being given, to find the Diſtance.*

The Rule 1. Take the Diſtance between the given Places in the Compaſſes.

2. Lay that Diſtance on the graduated Meridian, ſo that one Foot may be as many Degrees above the Parallel of the given Places, as the other below it; there ſtay the Compaſſes,

3. Count the Degrees between the Feet of the Compaſſes and it's the Diſtance required.

Example. *I demand the Diſtance from the* Lizard *in* England, *to* Pengwin Iſland *on the Coaſt of* New-found-land, *both being in the Latitude of* 50d. 00m. *North, or near it.*

Here the Diſtance from the *Lizard* to *Pengwin* Iſland, applied to the Meridian as directed, will reach from 36d. 30m. to 63d. 30m. the latter being as much above 50d. 00m. as the former is below it; and the Degrees intercepted are 27 Degrees, or 540 Leag. which is the Diſtance required. Or thus,

Take the Length of a Degree in the given Latitude, as here from 49d. 30m. to 50d. 30m. turn that over in a Streight-Line from the *Lizard* to *Pengwin* Iſland, and it's 27 times; which ſhews the Diſtance 27 Degrees as before.

Caſe 4. *Two Places differing in Latitude and Longitude being given, to find their Diſtance*

The Rule 1. Take their Difference of Latitude from the Equator.

2. Lay a Ruler on both given Places, apply that Diſtance ſo to the Ruler's Edge, that when one Foot is placed cloſe to the Ruler, and the other turned about, it may juſt touch ſome Eaſt and Weſt Line, croſſed by the ſaid Ruler's Edge, there ſtay the Compaſſes.

3. Then the Diſtance (by the Ruler's Edge) from the Place where the Compaſſes reſted, to that Place where the Ruler croſſeth the aforeſaid Eaſt and Weſt Line, meaſured on the Equator, giveth the Diſtance required.

Example.

I demand the Diſtance from the Lizard *to the* Iſland Berbadoes?

The *Lizard*'s Latitude is —— 50d. 00m. } by *Prob.* 1.
And *Berbadoes* Latitude is —— 13d. 00m. }
Their Difference of Latitude 37d. 00m.

Then take their Difference of Latitude 37 Deg. from the Equator, and laying a Ruler on both Places, apply one Foot of the Compaſſes ſo to the Ruler's Edge, that turning the other about, it toucheth an Eaſt and Weſt Line, croſſed by the Ruler; then the Diſtance (by the Ruler's Edge) from the Place where the Compaſſes reſted to the Place where the Ruler croſſeth the aforeſaid Eaſt and Weſt Line, meaſured on the Equator is 56d. 40m. or 1133 Leagues, the Diſtance required.

And here obſerve; the Meridian Line, and Line of Equal Parts next one another on the *Gunter*; the firſt is, or may be the Meridian, and Degrees of Latitude in a *Mercator*'s Chart; the latter, the Equator Line and Degrees of Longitude.

Thus much for the Uſe of *Mercator's-Chart*, Problems of Sailing by it is next ; but firſt ſome preparatory Problems in *Geography*.

Section II. *Some neceſſary Geographical Problems uſeful in* Mercator's-Sailing.

THeſe Problems properly belong to *Geography*, but are neceſſary in Sailing by Mr. *Wright*'s (commonly called *Mercator*'s) Chart, and for that Reaſon are placed here.

Note ; That all the Places mentioned in this Book, their Latitudes and Longitudes were taken from a Chart, Intituled, *A New and exact Chart, containing the Sea-Coaſt of* Europe, Africa, *and* America ; *from* England *to* Cape Bona Eſperance, *and from* New-found-land *to the* Straits *of* Magellan, *according to Mr.* Edward Wright's Projection, *and publiſhed by* J. Thornton, W. Fiſher, J. Seller, J. Colſon, *and* James Atkinſon.

This Chart has been new made and lately corrected, wherein the Longitude of Places is reckoned from the Meridian of *London*, agreeing with the *Mariners Compaſs Rectified* : As for the diſagreement that may be found between it and Tables of Latitude and Longitude in other Books, 'tis not to be regarded ; becauſe the Tables themſelves conſiderably differ from one another, as may appear by the following Problems.

Problem 1. The Latitude of two Places given ; to find their Difference of Latitude

Rule 1. If the two Places are upon the ſame Side of the Equtor, that is, both in North Latitude, or both in South Latitude ; ſubtract the leſſer Latitude from the greater, the Remainder is the Difference of Latitude.

Rule 2. If one Place be on one Side of the Equator, and the other Place on t'other Side ; that is, one Place in North Latitude, the other in South ; add the two Latitudes together, and the Sum is the Difference of Latitude.

Obſerve. 1. If a Ship ſails from a great North Latitude to a leſſer, ſhe ſails Southerly ; and if a Ship ſails from a leſs North Latitude to a greater, ſhe ſails Northerly, which is called raiſing the Pole.

2. If a Ship ſails from a great South Latitude to a leſſer, ſhe ſails Northerly; but if ſhe ſails from a leſs South Latitude to a greater ſhe ſails Southerly.

3. When a Ship croſſes the Equator, and ſails from North Latitude into South, the Difference of Latitude is Southerly; or if ſhe ſails from South Latitude into North, ſhe ſails Northerly.

Example 1. *I demand the Difference of Latitude between the* Lizard *and* Iſland Berbadoes.

The *Lizard*	Latitude	—— 50d. 00m.	North
I. *Berbadoes*		—— 13d. 25m.	

Their Diff. of Latitude by Subtraction 36d. 35m. equal to 2195 Minutes.

Example 2. *To find the Difference of Latitude between* Iſland Berbadoes *and* Iſland *St.* Hellena.

Iſland *Berbadoes*	in Latitude	—— 13d. 25m.	North
Iſland St. *Hellena*		—— 16d. 00m.	South

Their Diff. of Latitude by adding, is— 29d. 25m. equal to 1765 Minutes.

Problem 2. *The Latitude of one Place, and the Difference of Latitude between that and another Place being given; to find the Latitude of the latter Place.*

The Rule.

The Latitude, and Difference of Latitude given, being of $\left.\begin{array}{l}\text{One}\\ \text{a contrary}\end{array}\right\}$ Name, their $\left\{\begin{array}{l}\text{Sum}\\ \text{Diff.}\end{array}\right\}$ is the Latitude required.

Or thus in two Rules,

Rule 1. In $\left\{\begin{array}{l}\text{North}\\ \text{South}\end{array}\right\}$ Lat. ſailing to the $\left\{\begin{array}{l}\text{North}\\ \text{South}\end{array}\right\}$ ward, add the Difference of Latitude to the given Latitude, the Sum is the Latitude required, of the ſame Name.

Rule 2. In $\left\{\begin{array}{l}\text{North}\\ \text{South}\end{array}\right\}$ Lat. ſailing to the $\left\{\begin{array}{l}\text{South}\\ \text{North}\end{array}\right\}$ ward, ſubtract the leſſer from the greater, the Remainder is the required Latitude, of the ſame Name that the greater is.

Example 1. *Sailing from the* Iſland Berbadoes *North Eaſtward, until the Difference of Latitude be* 372 *Leagues; What Latitude is the Ship in?*

I *Berbadoes* Latitude is ———————13d. 25m. North
The Difference of Lat. 372 Leag. or 18d. 36m. Northerly
——— ———
Add, is the Latitude the Ship is in —32d. 01m. Northerly

Example 2. *From the* Lizard, *a Ship ſails South Weſtward, until the Difference of Latitude be* 137 *Leagues; what Latitude is the Ship in?*

The *Lizard* Latitude is ——————— 50d. 00m. North
The Difference of Latitude 137 Leag. 6d. 51m. Southerly
——— ———
The Lat. the Ship is in by Sub. is—43d. 09m. North

Example 3. *From St.* Hellena *a Ship ſails North weſtwards, until the Difference of Latitude be* 419 *Leagues; what Latitude is the Ship in?*

I. St. *Hellena* Latitude is ———————16d. 00m. South
The Difference of Lat. 419 Leag. or 20d. 57m. Northerly
——— ———
Latitude the Ship is in ———————4d. 57m. North

Problem 3. *The Longitude of two Places given; to find their Difference of Longitude.*

1. ACcording to the old Way of counting the Longitude, *The Rule* is thus;

Subtract the leſſer Longitude from the greater, the Remainder (if leſs than 180 Degrees) is the Difference of Longitude; but if the Remainder be more than 180 Degrees, ſubtract it from 360 Degrees, the laſt Remainder is the Difference of Longitude.

2. According to the new way of counting the Longitude in the *Mariners Compaſs Rectified. The Rule* is thus;

If both Longitudes be Eaſt, or both Weſt, ſubtract the leſſer from the greater, the Remainder is the Difference of Longitude; but if one be Eaſt, and the other Weſt, add them together, and the Sum if it exceed not 180 Degrees) is the Difference of Longitude; and when the Sum doth exceed 180 Degrees, ſubtract it from 360 Degrees, the Remainder is the Difference of Longitude required.

Example 1. *I demand the Difference of Longitude, between the* Lizard *and Iſland* Teneriffa, *one of the* Canary Iſlands.

		d.	m.
According to the old Account, Long. of	*Lizard* is	9	42
	I. *Teneriffa*	0	00
Their Difference of Longitude by Subtraction is		9	42
According to the *Mar. Compaſs* Long. of	*Lizard* is	5	24W
	I. *Teneriffa*	17	05W
Their Difference of Longitude by Subtraction is		12	41

The Difference of Longitude between theſe two Places, are very different in ſeveral Books, therefore all in this Book are taken from the *Chart* aforeſaid, or from the *Mariners Compaſs Rectified.*

Example 2. *What's the Difference of Longitude between the* Lizard *and I.* Berbadoes?

By the *Mariners Compaſs*, Longit. of *Lizard* is— 5d. 24m. W.

I. *Berbadoes* 53d. 04m. W.

Subtract is the Difference of Longitude —— 52d. 40m. equal to 3160 Minutes.

Problem 4. *To know when the Difference of Longitude between any two Places, is Eaſterly, or Weſterly.*

1. According to the old Way of counting the Longitude the Rule is thus;

If the Remainder (firſt found) be leſs than 180 Degrees, and you are bound to that Place which hath (of the two) the greater Longitude, then is the Difference of Longitude Eaſterly; but if you are to ſail to the leſſer, its Weſterly; And when the firſt Remainder is more than 180 Degrees, it's juſt the contrary.

2. According to the *Mariner's Compaſs Rectified*, The Rule is thus;

When the Longitude of the two Places are both Eaſt or both Weſt, and you are to ſail to the greateſt Longitude; then the Difference of Longitude is (according to the Name of the Longitude) Eaſt or Weſt. But if bound to the leſſer Longitude, then is the Difference of Longitude contrary, that is, Weſt in Eaſt Longitude, and Eaſt in Weſt Longitude: And if one Place lies in Eaſt Longitude, and t'other in Weſt, the Difference of Longitude between them, is according to the Name of that Longitude you are bound unto, that is, Eaſt, if to Eaſt Longitude; and Weſt, if to Weſt Longitude.

Prob.

Problem 5. *The Longitude of one Place, and the Difference of Longitude between that and another Place, being given; to find the Longitude of the laſt Place.*

1. ACcording to the old Way of counting the Longitude, the Rules are theſe following.

Rule 1. Sailing to the Eaſtward, add the Longitude and the Difference of Longitude together, the Sum, (but if exceeds 360 Degrees, ſubtract 360 Degrees therefrom, the Remainder) is the Longitude of the laſt Place.

Rule 2. Sailing to the Weſtward, ſubtract the Difference of Longitude from (but if the Difference of Longitude be the greateſt, add 360 Degrees to) the Longitude of the firſt Place, the Remainder is the Longitude required.

2dly, According to the new Way of counting the Longitude in the *Mariners Compaſs*; the Rules are theſe.

Rule 1. In Eaſt Longitude ſailing to the Eaſtward, and in *Weſt Longitude, ſailing Weſterly*; add, gives the Longitude of the laſt Place, (if it exceeds not 180 Degrees) agreeing with the Name of the firſt Place; but if it doth exceed, ſubtract it from 360 Degrees, the Remainder is the Longitude required of a contrary Name to the firſt.

Rule 2. In *Eaſt Longitude ſailing Weſterly*, and in *Weſt Longitude ſailing Eaſterly*: ſubtract, gives the Longitude of the laſt Place, whoſe Name agrees with the greateſt.

Example 1. *Sailing from* Berbadoes *North Eaſterly, till the Difference of Longitude be 275 Leagues, what Longitude is the Ship in?*

d m
By the *Mariner's Compaſs*, Long. of the *I. Berbadoes* is 58 04 W
The Difference of Longitude is 275 Leagues or — 13 45 E
Subtract, gives the Longitude the Ship is in — 44 19 W

Example 2. *From the* Lizard *a Ship ſails South Weſterly, till the Difference of Longitude be 352 Leag. What Longitude is the Ship in?*

d m.
By the *Mariners Compaſs* Longitude of the *Lizard* is 5 24 W
The Difference of Longtude is 352 Leagues —— 17 36 W
Add, gives the Longitude the Ship is in ——— 23 00 W

Thus much for the Preparation to *Sailing* by this *Chart*, the *Problems* are next.

Sect III. *Containing Problems of Sailing by Mr.* Wright's Chart, *commonly called* Mercator's *Sailing.*

IN the Working of theſe Problems, a *Table of Meridional Parts* is neceſſary; accordingly out of Mr. *Wright's Table*, have I drawn one to every fifth Minute of Latitude, counting the *Meridional Parts* in Miles, or Minutes of the Equator; which Table you will find placed before the *Table of Logarithms*, whoſe Uſe is to find the *Meridional Difference of Latitude*, between any two given Latitudes, and that is done by the next Problem: See *Page* 304.

Problem 1. *To find the Meridional Difference of Latitude, or the Difference of Latitude in Meridional Parts.*

The Rule is;

The Latitudes of $\left\{\begin{array}{l}\text{one ——}\\ \text{a contrary}\end{array}\right\}$ name, the $\left\{\begin{array}{l}\text{Diff.}\\ \text{Sum}\end{array}\right\}$ of the MeridionalParts(found by the Table of Meridional Parts) anſwering to the Degrees and Minutes of each Places Latitude, is the Meridional Difference of Latitude required.

Exam. 1. Iſl. Berbadoes *and St.* Thome, *an Iſland on the Coaſt of* Gabon *in* Africa: *What is the Meridional Difference of Latitude?*

					Minutes
Iſland	*Berbadoes*	Lati.	13d. 25m.N	Mer. Pts.	812
	St. *Thome*		00d. 00m,		000
Meridional Difference of Latitude					812

Example 2. *The* Lizard *and* Iſland Berbadoes: *What is their Meridional Difference of Latitude?*

					Min.
Lizard	Latitude	50d. 00m	N,	Merid.Parts	3474
I. Berbadoes		13d. 25m			812
Subtract, gives the Meridional Difference Latitude					2662

Example 3. Iſland Berbadoes *and* Iſland *St.* Hellena: *What is their Meridional Difference of Latitude?*

					Min.
Iſl.	*Berbadoes*	Lat	13d. 25m. N.	Merid. Parts	812
	St. *Hellena*		16d. 00m. S.		973

Add, gives the Meridional Difference of Latitude —— 1785

Problem 2. *The Latitude and Longitude of two Places given; to find their Courſe and Diſtance.*

Example, *What is the Courſe and Diſtance from the* Lizard *to the* Iſland Berbadoes.

		d m.		Min.		d m.
Lizard	Lat.	50.00 N	Mer.Pts	3474	Lon.	5.24 W.
I. Berbad.		13.25 N		812		58 04 W.
Diff. of Lat.		36.35 S.	Mer.Diff.Lat.	2662	Diff Lon.	52.40 W.
		60				60
		or 2195 Min.				or 3160 min

This Rectangle Triangle ABC (*Plate* 3. *Figure* 5.) is made by Problem 13. of *Practical Geometry*, after this manner.

1. From A repreſenting the Place ſailed from, lay the Meridional Difference of Latitude to B.

2. Draw BC perpendicular to AB, and thereon lay the Difference of Longitude from B to C,

3. From A to C (repreſenting the Place the Ship is come to) draw a Line, which concludes the Triangle ABC, Right-angled at B, whoſe Angle BAC meaſured on the Scale of Chords or Rumbs, ſhews the Courſe or Bearing of the two Places.

4. Take the Difference of Latitude, and lay it on the Meridian from A to D, and draw a Line DE, parallel to BC, to cut AC in E, and it's done: For if AE be meaſured on the ſame Scale AD was taken from, it ſheweth the Diſtance between the two Places.

But to reſolve it by *Trigonometry*, there are two Rectangle

Triangles, ABC, and ADE; in the former you muſt;

Note, 1. The Leg AB, is the Meridional Difference of Latitude.

2. The Leg BC, is the Difference of Longitude.
3. The Angle BAC, is the Courſe or Bearing.
4. The Angle ACB, is the Complement of the Courſe.

Secondly, And in the Rectangle Triangle ADE.

1. The Leg AD is the proper Difference of Latitude.
2. The Hypotenuſe AE, is the Diſtance of the two Places.
3. The Leg DE, is the Departure from the Meridian.
4. The Angle DAE, is the Courſe or Bearing.
5. The Angle AED, the Complement of the Courſe.

Theſe Things being premiſed, the Proportions are the ſame as in the *Doctrine of Plain Right-Angle Triangles*, as followeth:

1. For the Courſe, the Proportion is thus:

If the Leg A B is made Radius, then the Leg B C is the Tangent of the Angle BAC, and therefore it is,

As the Meridional Difference of Latitude, is to the Radius; ſo is the Difference of Longitude, to the Tangent of the Courſe: But more briefly thus;

Merid. Diff Lat. ·· Diff. Long. : : Radius .. T, of the Courſe
2662 Minutes ·· 3160 Min. : : T. 45d ·· T. 49d, 50m.

Which being turned into Points of the Compaſs, makes the Courſe to be S W. ½ W. nearly.

2. To find the Diſtance the Proportion is thus:

Making the Hypotenuſe AE Radius, the Leg AD is the Sine of the Angle AED, or the Sine Complement of the Courſe, and therefore *it* is,

As the Sine Complement of the Courſe, is to the proper Difference of Latitude; ſo is the Radius, to the Diſtance in the Rumb. Or more briefly thus;

S, c. Courſe ·· Diff. Lat. : : Radius ·· Diſtance required.
S. 40d 10m. ·· 2195 Min. : : S. 90d. .. 3417 Minutes.

Note, The Meridional Difference of Latitude may be found by the *Gunter's Scale* thus:

Extend the Compaſſes from the Latitude of 50d 00m. (on the Meridional-line) to the Latitude 13d. 25m. on the ſame

Line; that Extent meaſured on the *Line of Equal Parts*, will be $44\frac{4}{10}$m. or 2664 Minutes, the Meridional Difference of Latitude, which is but 2 Minutes more than by the Table.

Problem 3. *Both Latitudes and Courſe given; to find the Diſtance and Difference of Longitude.*

Example. A Ship ſails from the *Lizard*, and makes herCourſe (when Variation, Lee-way, *&c.* allowed for) to be S. 39d. W. or S. W. by S. ½ W. and then by Obſervation, is in Latitude 45d. 31m. North; I demand the Diſtance Run, and the Longitude ſhe is in?

		d. m.		Minutes
Lizard	Latitude	50 00N	Meridional Parts	3474
Obſerved		45 31N		3074

Difference of Lat. 4 29 Mer. Diff. Lat. —— 400
60

Or —— —— 269 Minutes

To delineate this, or any of the ſeven next Problems, by the Plain Scale. as alſo their Reſolutions by Trigonometry, the Directions and Notes in the foregoing Problem may be ſufficient Inſtructions, and therefore they are omitted till I come to Problem 10.

1. To find the Diſtance, the Proportion (as in *Plain Sailing*) is thus:

S. c. Courſe .. Diff. Lat. : : Radius .. Diſtance required.
S. 51d. 00m. .. 269 Min. : : S. 90d. .. 346 Minutes.

2. To find the Difference of Longitude, the Proportion is thus;

Radius .. T. Courſe : : Merid. Diff. Lat. .. Diff. of Longit.
T. 45d. .. T. 39 deg. : : 400 Minutes .. 325 Min. or 5° 25′

Or thus; the Extent on the Meridional Line (on the *Gunter*) from Latitude 50d. 00m. to Latitude 45d. 31m. meaſured on the *Line of Equal Parts*, is 6d. $\frac{7}{10}$m. the Meridional Difference of Latitude; and then you may ſay,

T. 45d. .. T. 39d. : : 6d. $\frac{7}{10}$. .. 5d. $\frac{4}{10}$. or 5d. 24m. the Difference of Longitude near as above.

3. Then to find the Longitude the Ship is in, it's thus,

Longitude ſailed from —— —— —— 5d 24m Weſt
Difference of Longitude 325 Minutes or —— 5d. 25m. Weſt

Longitude the Ship is in —— —— 10d, 49m. Weſt

Prob.

Problem 4. *Both Latitudes and Diſtance given; to find the Courſe, and Difference of Longitude.*

Example. If a Ship runneth 300 Minutes North Weſtward from a Port in Lat. 37d. N. and Longitude 10d. 25m. W. until ſhe be in Latitude 41 Degrees North: I demand the Courſe, and Longitude ſhe is in?

				Min.
Sailed from	Latitude	37d. North	Merid. Parts	2393
Ship is in		41d. North		2702
Difference of Latitude		4 North,	Merid. Diff Latit.	309
		60		

Or 240 Minutes

1. To find the *Courſe*, the *Proportion* (as in *Plain Sailing*) is thus;
Diſtance .. Radius : : Diff. Lat. .. Sc. Courſe
300 Min. .. S, 90d. : : 240 Min. .. S. 53d. 08m. Which
ſubtract from ——————— 90d. 00m.

Remainder is the Courſe ——————— 36d. 52m. North Weſterly 3¼ Points of the Compaſs, which makes the Courſe to be NW by N. ¼ W. neareſt.

2. To find the Diff. of Longitude, the Proportion is thus;
Radius .. T. Courſe : : Merid. Diff Lat. .. Difference Long.
T. 45d. .. T. 36d. 52m. : : 309 Minutes .. 232 Min. or 3d. 52m.

Or thus, the Extent (on the *Meridional Line on the Gunter*) from Latitude 37d. to Latitude 41d. meaſured on *Equal Parts*, is 5d. 10m. Meridional Difference of Latitude. And then ſay, T. 45d. .. T. 36d. 52m. : : 5d. $\frac{17}{100}$ .. 3d. 88 Parts of 100, or 3d. 52m. the Difference of Longitude as before.

Longitude ſailed from ——————— 10d. 25m. Weſt
Difference of Longitude is 232 Minutes or 3d. 52m. Weſt

Longitude the Ship is in ——————— 14d. 17m. Weſt

Problem 5. *Both Latitudes and Departure from the Meridian given; to find the Courſe, Diſtance and Difference of Longitude.*

Example. A Ship in Latitude 50d. 10m. North, and Longitude 5d. 24m. Weſt, ſails South Weſtward, till her Departure is 789 Minutes, and by Obſervation is in Latitude 39d. 20m. North: I demand the Courſe, Diſtance ſailed, and what Longitude the Ship is in?

The Proportion for the Courſe and Diſtance, are the ſame as in *Chapter* 3 *Section* 3. *Caſe* 6. of *Plain Sailing*, in *Page* 63, to which I refer you, and here omit them.

3. To find the Difference of Longitude the Proportion is ;

Lat. { Departed 50d. 10m. N / Ship is in 39d 20m. N } *Meridional Parts* { 2490 / 2571 } min.
Difference of Lat. 10d. 50m. S. Merid Diff. Lat. 919 min.
60
Difference Lat. 650 Minutes. Then you may ſay,
As *Diff. Lat.* ·· *Departure* : : *Merid. Diff. Lat.* .. *Difference of Long.*
As 650 Min ·· 789 Min. : : 919 Minutes ·· 1116m. or 18d. 36m

Or thus ; the Extent (on the Meridional-line on the *Gunter*) from Latitude 50d. 10m to Latitude 39d. 20m meaſured on the Line of Equal Parts, is 15d. 3 Tenths the Meridional Difference of Latitude. And then ſay,

As 650 Minutes ·· 789 Min. : : 15d. 3 Tenths ·· 18d. 6 Tenths or 18d. 36m. the Difference of Longitude as before.

Then to find the Longitude the Ship is in ; it's thus,
Longitude ſailed from — — 5d. 24m Weſt
Difference of Longitude 1116 Min. or — 18d. 36m. Weſt
Longitude the Ship is in — 24d. 00m. Weſt

Problem 6. *One Latitude, Courſe, and Diſtance given ; to find the Difference of Latitude, and Difference of Longitude.*

Example. *A Ship in Latitude* 42d. 30m. *North, and Longitude* 18d. 31m. *Weſt, Sails S E. by S.* 591 *Min. or* 197 *Leagues* : *I demand the Latitude and Longitude the Ship is in ?*

1. For the Difference of Latitude, the Proportion (by the *1ſt*) Caſe of *Plain Sailing* in *Page* 62 is thus ;

As Radius .. Diſtance : : Sc. Courſe ·· Difference of Latitude.
As S. 8 Points ·· 591 Min. : : S. 5 Pts ·· 491 Min. or 8d. 11m.
Latitude ſailed from —— 42d. 30m. N. Merid. Parts 2822m.
Diff. Lat. 491 Min. or 8d. 11m. S.
Latitude the Ship is in 34d. 19m N. Merid. Parts 2195m.
Subtract giveth the Meridional Difference of Latitude 627m.

Or thus ; The Extent (on the Meridional-line on the *Gunter*) from Latitude 42d. 30m. to Latitude 34d. 19m. meaſured

G on

on the Line of Equal Parts is 10d. $\frac{5}{10}$ or 10d. 30m. the Meridional Difference of Latitude.

To find the Difference of Longitude, the Proportion is,

As Radius ·· T: Courſe : : Merid. Diff. Lat. ·· Difference Long.
As T. 4Pts ·· T. 3Points : : 627 Minutes ·· 420m. or 7d. 00m.
Or thus;
As T. 4 Points ·· T. 3 Pts : : 10d. $\frac{5}{10}$ .. 7d Diff. Long as before
Longitude ſailed from ——— ——— 18d. 31m. Weſt
Diff. Long. 420 Minutes, or ——— ——— 07d. 00m. Eaſt
Longitude the Ship is in ——— ——— 11d. 31m. Weſt

Problem 7. *One Latitude, Courſe, and Departure given, to find the Diſtance, Difference of Latitude, and Difference of Longitude.*

Example. A Ship ſails ESE. from a certain Port in Latitude 50d. 10m. South, and Longitude 10d. 16m Eaſt, until the Departure from the Meridian be 957 Minutes: I demand her Diſtance Sail'd, the Latitude and Longitude ſhe is in?

The Diſtance is 1035 } Min. by *Chapter* 2. *Section* 3. *Pro-*
The Diff. of Lat. is 396 }
blem 3. of *Plain Sailing*, in *Page* 61. Then the Latitude the Ship is in, and the Meridional Difference of Latitude, is found thus.

	Min.
Latitude ſailed from 50d. 10m. South Merid. Parts ——	3490
Diff. Latitude 396m or 6d. 36m. S.	
Latitude Ship is in— 56d. 46m. S. Meridional Parts ——	4157
Subtract, giveth the Meridional Difference of Latitude	667

For the Difference of Longitude the Proportion is;

As Diff. Lat. ·· Departure ; : Merid. Diff. Lat. ·· Diff. of Long.
As 396 Min. ·· 957 Min. : : 667 Minutes ·· 1615m. or 26d 55m

Or thus; the Extent (on the Meridional Line on the *Gunter*) from Latitude 50d 10m. to Latitude 56d. 46m. meaſured on the Line of *Equal Parts*; it's 11d. $\frac{5}{10}$ the *Merid. Diff. of Lat.*

Then ſay,
As 396 Min. ·· 957 Min. : : 11d. $\frac{1}{16}$ ·· 27d. the Diff. Long.

Then to find the Longitude the Ship is in, it's thus;
Longitude ſailed from ——— ——— 10d. 16m. Eaſt
Difference of Longitude 1615 Min. or ——— 26d. 55m. Eaſt
Longitude the Ship is in ——— ——— 37d. 11m. Eaſt

Prob.

Problem 8. *One Latitude, Diſtance ſail'd, and Departure from the Meridian given, to find the Courſe, Difference of Latitude, and Difference of Longitude.*

Example. A Ship in Latitude 49d. 30m. North, and Longitude 14d. 40m. Weſt, ſails South Eaſtward 645 Minutes until the Departure from the Meridian be 500 Minutes: I demand the Courſe ſteered, the Latitude and Longitude the Ship is in?

1. The Courſe is 50d. 50m. SE. or SE $\frac{1}{2}$ E. }
2. The Diff. of Lat. 407 Min. or 6d. 47m. } by *Chapter* 3. *Section* 3. *Problem* 5. *of Plain Sailing in Page* 62. Then the *Latitude* the Ship is in, and the *Meridional Difference of Latitude* is found thus;

Min.
Latitude ſailed from — 49d. 30m. N. Merid. Parts 3428
Diff. Lat. 407 Min. or — 6d. 47m. S.
Latitude the Ship is in 42d. 43m N. Merid. Parts 2840
Meridional Difference of Latitude ——— ——— ——— 588

3. To find the Difference of Longitude the Proportion is;
As Diff. Lat. .. Depart. : : Merid. Diff. Lat. .. Diff. of Long.
As 407 Min. .. 500Min. : :588Minutes .. 722 Min. or 12d.2m.

Or thus, the Extent (on the Meridional-line on the *Gunter*) from Latitude 49d. 30m. to Latitude 42d. 43m. meaſured on Equal Parts, is 9d. $\frac{8}{10}$, the Meridional Difference of Latitude. Then ſay,

As 407 Min. .. 500 Min. : : 9d. $\frac{8}{10}$ .. 12d. the Diff. Long.

Then to find the Longitude the Ship is in, it's thus;
Longitude ſailed from ——— ——— ——— 14d. 40m. Weſt
Diff. Longitude 722 Minutes, or ——— ——— 12d. 02m. Eaſt
Longitude the Ship is in ——— ——— ——— 2d. 38m. Weſt

Problem 9. *One Latitude Courſe, and Differenze of Longitude given; to find the Diſtance, and Difference of Latitude.*

Example. A Ship ſails S. W. by W. from the *Lizard*, until ſhe be in Longitude 57d. 26m. Weſt: I demand the Latitude the Ship is in, and her Diſtance ſail'd?

Longitude ſailed from ——— ——— ——— 5d. 24m. Weſt
Longitude the Ship is in ——— ——— 57d. 26m. Weſt
Subtract and Remainder is the Diff. Longit. 52d. 02m. Weſt
60

Or 3122 Minutes

1. For the Mer. Diff. of Lat. the Proportion may be thus;
As T. Courſe ·· Radius : : Differ. Long ·· Merid. Diff of Lat.
As T. 5 Pts. ·· T. 4 Pts : : 3122 Minutes ·· 2085 Minutes.
Latitude ſailed from 50d. its Merid Parts —— 2474 ſubtract
Giveth the Mer. Pts for the Lat. the Ship is in 1389 which ſeek in the Table of *Meridional Parts*; againſt it you will find 22d. 33m. the Latitude the Ship is in North.

Or thus, on the *Gunter*; take the Meridional Difference of Latitude, being 2085 Minutes, or 34d. 45m. from the Line of Equal Parts, and ſet it from the Latitude departed from; being 50d. 00m. in the Meridional Line, decreaſing (becauſe it's North Latitude, and ſailing Southerly) and it reacheth (in the ſame Line) to 22d. 30m. the Latitude the Ship is in, very near to the Laritude found above by the Table of Meridional Parts, differing from it but 3 Minutes.

Then having both Latitudes known, the Difference of Latitude is found (by ſubtracting the leſſer from the greater) to be 27d. 27m, or 1647 Minutes, or 549 Leagues.

2. Find the Diſtance Sailed by *Chapter* 3. *Sect* 3. *Problem* or *Caſe* 2, of *Plain Sailing*, in Page 61.

Problem 10. *Two Places in one Parallel or Latitude, their Difference of Longitude given; to find their Diſtance.*

Example. I demand the Diſtance between the *Lizard* and *Pengwin Iſland* on the Coaſt of *Newfound-land*.

Lizard —— } Longit. is { 53d. 24m. West
Pengwin Iſland } { 53d. 10m. West

Subtract, and Remainder is Diff. Long. —— 47d. 46m. West
60

Difference of Long. 47d. 46m. or —— 2866 Minutes

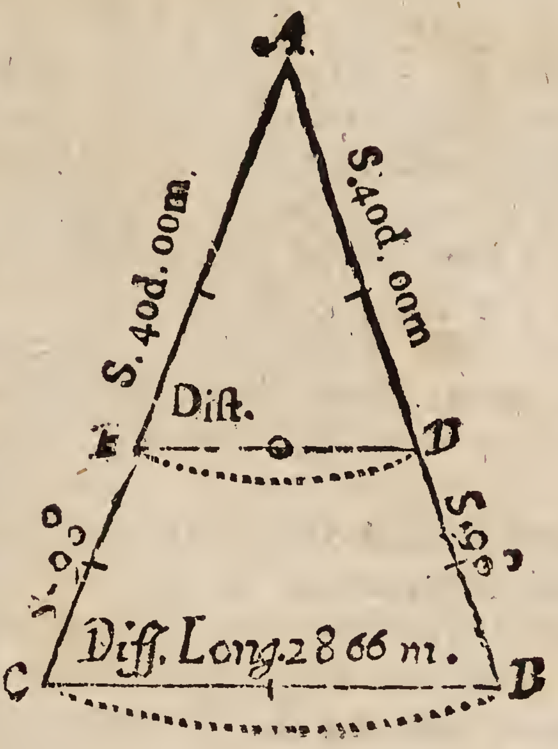
Theſe Places are both (ſuppoſed to be) in Latitude 50d. 00m. North, whoſe Complement is 40d. 00m.

To delineate this Problem by the Plain Scale.

1. Draw the Prick'd Arch BC, with the Sine of 90 Degrees, one Foot being in the Center A.

2. Lay the Difference of Longitude on that Arch from B to C, and draw the Lines AB, AC, and BC.

3. With



3. With the Sine Complement of the Latitude, and one Foot in A, draw the Arch DE: that is, take the Complement of the Latitude from the Sines, and with one Foot on A, draw the prick'd Arch D E, to cut A B in D, and AC in E.

4. Draw a Line from D to E, and it's done; for D E being meaſured on the ſame Scale B C was taken from, will ſhew the Diſtance required.

The Explanation of the Scheme.

1. A repreſents one of the Poles of the Earth.
2. The Arch BC, is the Equator.
3. The Arch DE, is a Parallel of Latitude.
4. The Line ADB, is the Meridian of the *Lizard.*
5. The Line AEC, is the Meridian of *Pengwin-Iſland.*
6. D is the *Lizard* } in the Latitude of 50d. 00m
7. E is *Pengwin-Iſland* } in the Latitude of 50d. 00m
8. The Line BC is the Difference of Longitude.
9. The Line DE is their Diſtance in that Parallel of Latitude.

Then to find their Diſtance, the Proportion is, by the 4*th* Propoſition of the ſixth Book of *Euclid.*

As A B, is to BC; ſo is AD, to DE. And Alternately

As AB, is to AD; ſo is BC, to DE. That is,

As Radius, is to the Sine Complement of the Latirude; ſo is the Difference of Longitude, to the Diſtance in that Parallel of Latitude. In ſhort thus;

As Radius ·· Sc. Latitude : : Diff. Long. ·· Diſt.

As S. 90d. ·· S. 40d. 00m : : 2866 Min. ·· 1842 Minute

Or thus; By *the Plain-Scale.*

Take the Latitude of 50d. 00m. from the *Scale of Chords*, and meaſure it from 60 on the *Scale of Longitude* marked (ML) and it ſheweth Minutes 38.6 Tenths make a Degree of Longitude in that Latitude, Then ſay,

As 1 Deg. .. Min. 38.6 :: Diff. Long 47d. $\frac{76}{100}$ .. 1842 Minutes the Diſtance as before.

Problem 11. *Two Places in one Latitude, their Diſtance given; to find their Difference of Longitude.*

Example. If a Ship ſails Weſt 390 Minutes from the *Lizard*; What Longitude is ſhe in?

To delineate the Problem by the *Plain-Scale.*

1. Take 90 degrees from the *Scale of Sines*, and with one Foot on A, draw the pricked Arch BC.

2. From the *Scale of Sines* take the Complement of the given Latitude, and ſetting one Foot on A, draw the pricked Arch DE.

3. Then from any *Scale of Equal Parts*, take (the Diſtance Run) and lay it on the laſt Arch from D to E.

4. From A draw Lines through D, and E, to cut the Arch BC, in B, and in C.

5. Then draw a Line from B to C, and it's done; for BC being meaſured on the ſame Scale DE was taken from, will ſhew the Difference of Longitude required.

The Proportion (by the 4th Propoſition of the 6th Book of *Euclid*) for the Difference of Longitude is,
As Sc. Latitude .. Radius :: Diſtance .. Difference of Longit.
As S. 40d. 00m. .. S. 90d. :: 390Min. .. 607 Min. or 10d. 07m.

Or thus; by the *Plain Scale.*

The Latitude 50d. 00m. (taken from the *Chords*) and meaſured on the Scale ML, ſheweth Minutes 38 6 Tenths make a Degree of Longitude in that Latitude: Then ſay,
As Min. 38.6 Tenths .. 1d. :: 390m. .. 10d. $\frac{1}{10}$ or 10d. 06m. Diff. Long. differing but one Minute from that found before.

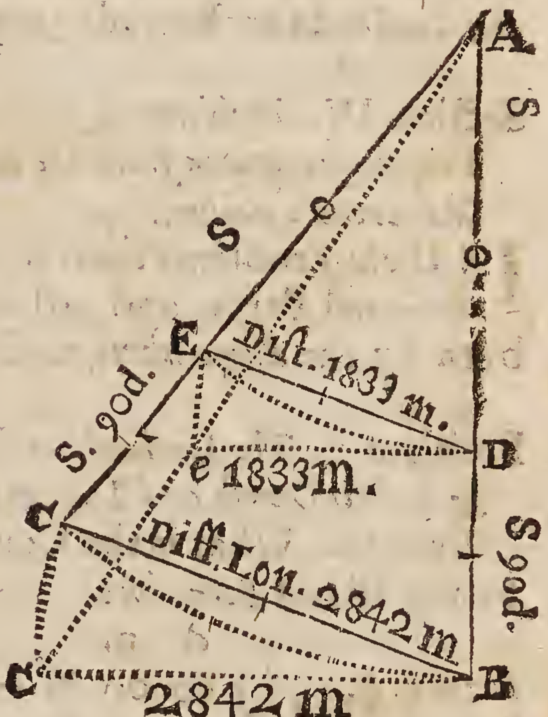
Longitude of the *Lizard* ——— ———	05d. 24m. Weſt
Difference of Longitude 607 Minutes, or ——	10d. 07m Weſt
Add gives the Longitude the Ship is in ——	15d. 31m. Weſt

Prob.

Problem 12. *Two Places in one Parallel or Latitude, their Diſtance, and Difference of Longitude given; to find the Parallel or Laitude,*

Example. *Suppoſe two Ships in the Equator* 2842 *Minutes aſunder, and they both ſail North alike Diſtance, till they are but* 1833 *Minutes aſunder: I demand what Latitude they are now in?*

To delineate this Problem *by the* Plain Scale.



1. Draw the prick'd Arch BC with the Sine of 90 Degrees one Foot being on the Center A, to cut the Line AB in B.

2. On B erect the prick'd perpendicular Bc, and thereon lay the Difference of Longitude from B to c.

3. Draw the prick'd Line A c.

4. Then with the Diſtance in the Parallel, and one Foot in the prick'd Line Ac, moved upon that Line, till the other Foot turned about, will but juſt touch the Line A B, and where the former Foot reſteth which is at e, there ſtay it.

5. Take the neareſt Diſtance from e, to the prick'd Line B c, and lay that Diſtance on the Line AB, from B to D, and draw the prick'd Line D e.

6. Lay the Difference of Longitude on the prick'd Arch, made with the Sine of 90 Degrees, from B to C, and draw the Line AC; alſo with the Diſtance AD, and one Foot on A, draw the prick'd Arch DE to cut AC in E; likewiſe draw Lines from B to C, and from D to E, and it's done; for AD or AE meaſured on the Scale of *Sines*, will ſhew the Complement of the Latitude required.

Note; If B c be equal to B C, and D e, equal to D E, it's done true, otherwiſe not; as the prick'd Arches c C and e E manifeſteth.

To find the Latitude (by the foreſaid Propoſition of *Euclid*) the Proportion is thus;

As Differ. Long. ·· Diſtance : : Radius ·· S. c. Latit. required.
As 2842 Min. ·· 1833 Min. : : S. 90d. ·· S. 40d. 10m.
Which ſubtracted from ——— ——— 90d. 00m.
The Remainder is the Parallel of Latitude 49d. 50m. North

Or thus, *By the Plain Scale.*

As 2842 Min. ·· 1833 Min. : : 60 Min. ·· Min. 38.7 Tenths making one Degree of Longitude, in the Latitude required.

Then from the *Scale of Longitude* (marked ML) take Min 38.7 Tenths, meaſure it on the *Scale of Chords*, and it ſheweth the Latitude to be 49d. 50m. as before.

Section IV. *Problems of ſailing by the Middle Latitude; or a Proportion drawn from the Middle Latitude, nearly agreeing with* Mercator'*s Sailing.*

IN theſe Problems there's no Uſe made of the Table of Meridional Parts, and all its Proportions may be wrought both by the *Logarithms*, and *Gunter's Scale.*

Problem 1. *The Latitude and Longitude of two Places given; to find their Courſe and Diſtance.*

Example. What is the Courſe and Diſtance from the *Lirard* to the Iſland *Berbadoes.*

		d m		d m		d m
Liznrd.	Lat.	50 00 N	——	50 00	Long.	5 24 W
Barbad.		13 25 N	——	13 25		58 04 W

Difference Latit. 36 35 S. Sum is 63 25 diff. long. 52 40 W
60 Mid Lat. 31 42 60
Minutes 2195 ſubt. it from 90 00 or, 3160 Min.
Comp. Mid. Lat. 58 18

To delineate the Problem by the Plain Scale. *Plate 2. Fig 6.*

1. Make AD upon the Meridian equal to the Difference of Latitude.

2 Draw the prick'd Arch IK with the Sine of 90 degrees (one Foot being on A) to cut the Meridian AD in I.

3. With the Sine Complement of the Middle Latitude and one Foot on A, draw the prick'd Arch GH. to cut the Meridian in G.

4. On the laſt Arch, lay ½ the Difference of Latitude, from G to H.

5. By A and H draw a Line, to cut the firſt Arch (made with the Sine of 90 Degrees) in K.

6. Lay IK twice on the Meridian, from A to B.

7. On B erect a Pependicular, and thereon lay the Difference of Longitude; from B to C.

8. Draw a Line from A to C: and from D, draw DE parallel to BC, to cut AC in E, and its done. *Plate* 3. *Fig.* 6.

Then is the Leg AD the Difference of Latitude.
Leg BC the Difference of Longitude.
Hypot. AE the Diſtance of the two Places
Leg DE the Departure, according to the *Plain Chart.*
Angle DAE, or BAC the Angle of the Courſe or Bearing.
Angle AED the Complement of the Courſe.

1. To find the Courſe, or Bearing, the Proportion is;

As the Difference of Latitude, is to the Difference of Longitude; ſo is the Sine Complement of the Middle Latitude, to the Tangent of the Courſe. Or more briefly thus,

As Diff. Lat. .. Diff. Long. :: Sc. Middle Lat. .. T. Courſe
As 2195 min. .. 3160 Min. :: S. 58d. 18m, .. T. 50d 45m

By *Gunter.* The Extent from 2195 Minutes to 3160 Minutes on *Numbers*, being laid (increaſing) from Sine 58d 18m reacheth beyond the Sine of 90d, wherefore lay that Extent from the Sine of 90 Degrees towards the Left-hand, and ſtay one Foot there, then bring in the other Foot to the Sine Complement of the Middle Latitude 58d. 18m. this laſt Diſtance, of the Compaſſes lay from Tangent of 45 Degrees, and it ſheweth on Tangents 50d. 45m. the Courſe S W ½ W. neareſt, which is the Courſe from the *Lizard* to *Berbadoes.*

Or thus; by two Proportions to find the Courſe.

Firſt, As the Radius, is to the Sine Complement of the Middle Latitude; ſo is the Difference of Longitude, to the Departure from the Meridian, or Meridional Diſtance. More briefly thus;

As Radius .. S.c. Middle Lat. :: Diff. Long. .. Departure
As S. 90d. .. S. 58d. 18m. :: 3160 Min. .. 2685 Min.

Secondly, As the Difference of Latitude, is to the Departure from the Meridian; ſo is Radius, to the Tangent of the Courſe.

Or more briefly thus;

As Diff. Lat ·· Departure : : Radius ·· T. Courſe

As 2195 Min. ·· 2685 Min. : : T. 45d ·· T. 50d. 45m. as before

2. To find the Diſtance, the Proportion is;

As S c. Courſe ·· Diff Lat. : : Radius ·· Diſtance required.

As S. 39d. 15m. ·· 2195 Min. : : S. 90d. ·· 3467 Minutes.

Problem 2. *Both Latitudes and Courſe given; to find the Diſtance, and Difference of Longitude.*

Example. *Suppoſe a Ship ſails from the* Lizard, *and made (when* Variation Lee-way, *&c. allowed for) her Courſe South* 39d. *Weſt, or S W by S* ½ *W. and then, by Obſervation, is in Latitude* 45d. 31m. *North, what's her Diſtance Run, and Longitude ſhe is in?*

d m.
Lizard } Latitude { 50d 00m North ———— 50 00
Obſerved } Latitude { 45d 31m North ———— 45 31
Difference of Latitude 4d 29m Sum both Lat 95 31
or 60 The ½ is the Mid. Lat. 47 45
Diff. Lat. is Minutes 269 Which ſubt. from 90 00
The Remainder is Compl. of the middle Latitude —— 42 15

To delineate this or any of the following Problems by the *Plain Scale*, the Inſtructions in the foregoing are ſufficient to inform the diligent Learner.

1. The Diſtance is 346 Minutes by *Chapter* 3. *Section* 3. *Prob.* or *Caſe* 2. of *Plain Sailing*, in *Page* 61.

2. To find the Difference of Longitude, the Proportion is;

As the Sine Complement of the *Middle Latitude*, is to the Tangent of the Courſe; ſo is the *Difference of Latitude*, to the *Difference of Longitude*. Or thus;

As S c. *Mid Lat* ·· T. Courſe : : Diff. Lat. ·· Difference Longit.

As S. 42d 15m. ·· T. 39d. : : 269 Min. ·· 324 Min.

To work this, or any ſuch like Proportion, by *Gunter's Scale*, the General Rule of extending from the firſt Term to the Second, *&c.* will not ſerve, till the firſt and ſecond Terms are reduced to one *Line* or *Scale*, and that is by this Rule following.

A General Rule to reduce the ſecond Term Tangent, *to the firſt* Term Sine.

Extend the Compaſſes from Tangent 45d. to the Tangent of the Second Term; lay that extent on the *Line of Sines*, from 90d. if the Second Term be leſs than 45d. but if more, from the

Firſt Term towards the Left-hand ; and where the Foot reſteth, I call the Second Term reduced to the Firſt, and is to be counted inſtead of the Second Term, as for Example.

To work the foreſaid Proportion, for to find the Difference of Longitude.

1. The Extent from Tangent 45d. to Tangent 39d. laid from Sine 90d. reacheth to Sine 54d. 05d. the Second Term reduced to the Firſt Term.

2. The Extent from Sine 54d. 05m. (the Second Term reduced) to Sine 42d. 15m. the Firſt Term in the Proportion ; laid on the Line of *Numbers* from 269 Minutes the third Term, will reach to 324 Minutes the Fourth Term, the Difference of Longitude required.

Or thus, by two *Operations* to find the Difference of Longitude.

Firſt ; As the Sine Complement of the Courſe, is to the Difference of Latitude ; ſo is the Sine of the Courſe, to the Departure from the Meridian, or Meridian Diſtance. Or thus ;

As S. c. Courſe .. Diff. Lat. : : S. Courſe .. Departure.
As S. 51 Degrees .. 269 Min. : : S. 39 Deg. .. 218 Min.

Secondly ; As the Sine Complement of the Middle Latitude, is to Radius ; ſo is the Departure from the Meridian, to the Difference of Longitude. Briefly thus ;

As Sc. Middle Lat. .. Radius : : Departure .. Diff. Longit.
As S. 42d. 15m. .. S. 90d. : : 218 Min. .. 324m. as before

Then to find the Longitude the Ship is in, it's thus,

Lizard Longitude is ——— 05d. 24m. Weſt
Diff. Longitude 324 Minutes, or ——— 05d. 24m. Weſt

Longitude the Ship is in ——— 10d. 48m. Weſt

Problem 3. *Both Latitudes, and Diſtance given ; to find the Courſe, and Difference of Longitude.*

Examp. If a Ship runneth 300 Minutes North Weſterly, from a Port in 37deg. North Latitude, and Longitude 10d. 25m W until ſhe be in Latitude 41 degrees North. What is her Courſe, and Longitude ſhe is in ?

Sailed from } Latitude { 37d. North ——— 37d.
Ship is in — } Latitude { 41d. North ——— 41d.

Difference of Latitude —— 4d N. Sum of both Latit. 78d.
60 Middle Latit. ——— 39d.
Diff. Latitude is Minutes 240 Subtract from ——— 90d.
Complement of the Middle Latitude ——— 51d.

1. The Courſe is North 36 deg. 52 min. Weſt, or NW by N ¼ W. neareſt; found by *Chap.* 3. *Section* 2. *Caſe* 4. of *Plain Sailing*, in Page 62.

2. To find the Differ. of Longitude, the Proportion is thus,
As Sc. Middle Lat. ·· T. Courſe : : Diff Lat. ·· Diff Longit.
As S 51 degrees ·· T. 36d. 52m : : 240 Min. ·· 232 Min.

By *Gunter's Scale*. The Extent from Tangent 45d. to Tangent 36d, 52m, will reach from Sine 90d. to Sine 48d. 30m, the Second Term reduced to the Firſt. Then the Extent from this laſt (Sine 48d. 30m) to Sine 51d. (the Firſt Term in the aboveſaid Proportion) will reach on the Line of *Numbers* from the Difference of Latitude 240 Minutes, to 232 Minutes, or 3d. 52m the Difference of Longitude.

Or thus; by two Proportions (after the Courſe is found) as before to find the Difference of Longitude, ſay,

1. As the Radius, is to the Diſtance Run; ſo is the Sine of the Courſe, to the Departure from the Meridian. Which briefly is thus;
As Radius ·· Diſtance : : S Courſe ·· Departure
As S 90d. ·· 300 Min : : S 36d 52m ·· 180 Minutes

2. As the Sine Complement of Middle Latitude is to Radius; ſo is the Departure from the Meridian, to the Difference of Longitude. Briefly thus;
As Sc. Mid Lat. ·· Radius : : Departure ·· Diff. Longitude
As S. 51 deg. ·· S. 90d. : : 180 Min. ·· 232 Min.

Or it may be found by this Proportion when the Diſtance is given.
S c Middle Lat ·· Diſtance : : S. Courſe ·· Diff. Longitude
S. 51 degrees ·· 300 Min. : : S. 36d. 52m ·· 232 Min.

Then to find the Longitude the Ship is in, it's thus;
Longitude the Ship ſailed from ——— 10d. 35m. Weſt
Diff. Longitude 232 Minutes, or ——— 3d. 52m. Weſt

Longitude the Ship is in ——— 14d, 27m. Weſt

Problem 4. *Both Latitudes and Departure from the Meridian given; to find the Courſe, Diſtance, and Difference of Longitude.*

Example. A Ship in Latitude 50d. 10m. North, and Longitude 5d. 24m. Weſt; ſails South Weſterly, till the Departure be 789 Minutes, and ſhe be in Latitude 39d. 20m. North. I demand the Courſe, Diſtance and Longitude the Ship is in?

Latitude { Sailed from 50d. 10m. North —— 50d. 10m.
{ Ship is in 39d. 20m. North —— 39d. 20m.

Difference of Latitude—10d· 50′ Sum of both Lat 89d 30m
60

Or Minutes ———— 650 The ½ is the Mid. Lat. 44d. 45m.
Which ſubtract from —— 90d. 00m

The Remainder is Complement Middle Latitude 45d. 15m
1. The Courſe is S. 50d. 30m. W. } by *Chapter* 3. *Section* 3.
2. The Diſtance 1022 Minutes } *Problem* or *Caſe* 6, of *Plain Sailing* in *Page* 63.

3. To find the Difference of Longitude, the Proportion is;

As Sc. Mid. Lat ·· T. Courſe :: Diff. Lat ·· Diff. Longit.
As S. 45d. 15m ·· T. 50d. 30m :: 650 Min. ·· 1111 Minutes

For the Extent from Tangent 45d. to the Tangent 50d. 30m laid (on the *Line of Sines*) from 45d. 15m. reacheth to Sine 35d. 50m. the Second Term reduced to the firſt. Then the Extent from this laſt (Sine 35d. 50m.) to S. 90d. (inſtead of Sine 45d. 15m. the firſt Term in the above Proportion, always ſo when the Courſe is more than 45d. and that) laid on the *Line of Numbers*, from Diff Lat. 650 Minutes, will reach to 1111 Minutes the Difference of Longitude required.

Or thus; the Difference of Longitude may be found without knowing the Courſe, ſaying;

As the Sine Complement of the Middle Latitude, is to the Radius; ſo is the Departure from the Meridian, to the Difference of Longitude. That is,

As Sc. Middle Lat. ·· Radius :: Departure ·· Differ. Longit.
As S. 45d. 15m. ·· S 90deg. :: 780 Min. · 1111 M. as before

Then the *Longitude* the Ship is in, may be found, as in *Problem* 5. of *Mercator's Sailing*, Page 96, that being the ſame Queſtion with this.

And in like manner all the remaining Queſtions in *Mercator*, may be wrought by the Sine Complement of the Middle Latitude, which I leave to the Learners Practice: And thus, much may ſuffice for the *Second kind of Sailing* or *Second Part of Navigation*, and the Application of *Plain Trigonometry*; *Spheric Trigonometry* is next.

CHAP.

Chapter V *Containing the Doctrine of Spheric Triangles, Rectangular, and Oblique, both Geometrical and Arithmetical.*

BEfore I enter on *Spheric Trigonometry*, as to the framing and working of Proportions therein, it will be neceſſary you ſhould underſtand how to make a Spheric Triangle, and to meaſure any of its Parts: In Order thereunto, I have contrived the following Problems, which I call *Spheric Geometry.*

Section I. Spheric Geometry *explained by Definitions and Problems.*

Definition 1. *SPheric Geometry*, is that by which the Circles of the Sphere are deſcribed, drawn or projected on a Plain:

2. A *Sphere* or *Globe*, is a round Body, made by the moving of a Semi-circle about its own Diameter, till the Motion end where it began.

3. The *Projection of the Sphere*, is either Arthographical, Sterographical, or Gnomonical.

4. *Arthographical*, is the drawing the Superficies of the Sphere on a Plain, which cutteth the Sphere in the middle, with reſpect to the Eye being placed perpendicular to it, and at an Infinite Diſtance therefrom: This Projection maketh uſe only of a *Scale of Chords*, and of *Sines.*

5. *Stereographical*, ſheweth how to deſcribe the Sphere's Superficies on a Plain, which cutteth it in the middle, with reſpect to the Eye being placed in the Sphere's Superficies, perpendicular to the Center of the ſaid Plain.

6. *Gnomonical Projecting the Sphere*, is drawing the Superficies on a Plain touching it, with reſpect to the Eye being placed in the Sphere's Center.

Theſe two laſt make uſe of a *Scale of Chords, Tangents*, and *Secants.*

7. All Circles of the Sphere, are either Great Circles, which cut it in two equal Parts; or Leſſer Circles, which cut it in two unequal Parts.

8. The Plain on which the Sphere is projected, is that Circle which bounds or limits the Projection, and is repreſented by the Circle ABCDEBA. *Plate* 3. *Fig* 7.

9. A *Great Circle*, is either the Primitive Circle, a Right Circle, or an Oblique Circle.

Theſe Circles conſidered ſeverally, or jointly, afford divers *Problems*, which are the ſubject matter of *Spheric Geometry*, and are ſuch as follows.

Problem I. *To find the Pole of any Great Circle.*

Definition 1. A *Great Circle*, is either the Primitive Circle, as BCDEB; or a Right Circle, as the Diameter BAD; or an Oblique Circle, as the Arch BFD. *Plate* 3. *Fig.* 7.

2. The *Pole of a Great Circle*, is a Punct every way 90 Degrees diſtant from it. And.

Note 1. The Pole of a *Great Circle*, is either upon the Primitive Circle, or within it.

2. When the Pole is within, it's either at the Primitive Circle's Center, or not.

In this Problem, are three Caſes.

Problem I. Caſe 1. *The Pole of the Primitive Circle is required.*

Example. BCDE The Primitive Circle given; to find the Pole thereof is required. *Plate* 3. *Fig.* 7.

The Rule. Find A, the Center of the Primitive Circle BCDE, which Center A is the Pole required.

Problem I. Caſe 2. *The Pole of a Right Circle is required.*

Definition. A *Right Circle* paſſeth through the Center of the *Primitive Circle*, and in the Projection is a Diameter; as BAD.

Note, A *Right Circle* hath its Pole on the Primitive Circle.

Example. The Pole of the Right Circle BAD is required. *Plate* 3. *Fig.* 7.

The Rule. From the Chords lay 90 Degrees on the Primitive Circle from B or D, both ways to C, or E: I ſay C, or E, are the Poles of the Right Circle BAD.

Problem I. Caſe 3. *The Pole of an Oblique Circle is required.*

Definition. An *Oblique Circle* paſſeth not through the Center of the Primitive Circle, and in the Projection is repreſented by an Arch; as BFD. *Plate* 3. *Figure* 7.

Note 1. The Poles of an Oblique Circle, is in a Diameter which paſſeth through its Center.

2. One of the Poles of an Oblique Circle, lieth between the Centers of the Primitive, and Oblique Circles.

3. Every Great Circle, whether Right, or Oblique, cutteth the Primitive, diametrically oppoſite.

Example.

$$\left.\begin{array}{l}\text{BCDE the Primitive}\\ \text{BFD the Oblique}\end{array}\right\}\text{Circle and}\left\{\begin{array}{c}\text{A}\\ \text{Y}\end{array}\right\}\text{its Center given.}$$

The Pole of an Oblique Circle BFD *is required. Plate* 3. *Fig.* 7.

The Rule 1. Through A and Y, draw a Diameter, to cut the Primitive Circle in C and E, and the Oblique Circle in F.

2. Lay a Scale on B and F, to cut the Primitive Circle in G; which is called Reducing F to the Primitive Circle.

3. Take 90 Degrees (from the *Scale of Chords*) and lay it on the Primitive Circle, from G both ways to H.

4. Reduce H to the Diameter CAE, by laying a *Scale* on B and H, to cut the Diameter CAE in I, both within the Primitive Circle and without, either of which Points I is the Pole of the Oblique Circle BFD.

Problem 2. *To Deſcribe a Spheric Angle.*

Definition. A *Spheric Angle*, is made by the interſection of two Great Circles; the interſection being the Angular Punct.

Note. In this Problem are two Caſes.

Problem 2. Caſe 1. *To make an Angle, that the Angular Punct may be at the Center of the Primitive Circle.*

The Rule. Such an Angle is made (in all reſpects) like a Plain Angle.

Example. An Angle *BAC* equal to 40d. 30m. (whoſe Angular Punct *A* may be the Center of the Primitive Circle) is required to be made. *Plate* 3. *Fig.* 8.

1. With a Chord of 60 Degrees (on the Center A) deſcribe the Primitive Circle, BCDE.

2. On the Primitive Circle, and from the ſame *Chords*, make BC equal to 40d. 30m.

3. From B and C draw two Right Circles, or Diameters thro' A, which will conclude the Angle *BAC* required to be made.

Prob. 2. Caſe 2. *To make an Angle, that the Angular Punct may be at the Primitive Circle.*

The Rule. Such an Angle is made by drawing an Oblique Circle with the Secant of the given Angle.

Examp.

Example. *An Angle* EBF *equal to* 34*d.* 30*m.* (*whoſe Angular Punct* B *may be at the Primitive Circle*) *is required to be made?* Plate 3. Fig. 7.

1. Deſcribe the Primitive Circle BCDE, as before directed.

2. Lay a Scale on A the Primitive Circle's Center) and cut the Primitive Circle in B, and D.

3. With the Secant of the given Angle) 34d. 30m. and one foot in B, deſcribe the Arch Y.

4. With the ſame, and one Foot on D croſs the former Arch Y in Y; the Center of the Oblique Circle BFD. which will conclude the Angle EBF equal to EDF, required to be made.

Note; When the given Angle is Obtuſe, ſubtract it from 180 Degrees, and with the Remainder make the Angle as above directed, and it's done.

Prob. 3. *To draw a Great Circle through any given Punct, ſo that it ſhall make at the Primitive Circle any given Angle.*

The Rule 1. With the Tangent of the given Angle, and one Foot in the Center of the Primitive Circle, make an Arch.

2. With the Secant of the ſame, and one Foot in the given Punct, cut the former Arch, which croſſing, is the Center of the Circle required to be drawn.

Example. *Plate* 3. *Fig.* 7.

BCDE the Primitive Circle }
A the Center thereof —— } given:
F the Punct —— }

Through F, to draw an Oblique Circle, that it may make an Angle at the Primitive Circle, equal to 34d. 30m is required?

Note: The given Point muſt be ſo far from the Center of the Primitive Circle, that the Tangent from the Center, and the Secant (of the ſame) from the given Punct, may interſect each other; otherwiſe it's impoſſible.

1. With the Tang. of 34d. 30m. and one Foot in A, make an Arch Y.

2. Then with the Secant of the ſame, and one Foot in F, cut the Arch Y in Y; the Center of the Oblique Circle BFD, required to be drawn; and if B, and D, are Diametrically oppoſite, it's done true, otherwiſe not.

Prob. 4. *To draw a Great Circle through any two Puncts given, either both within the Primitive Circle, or one within, and the other without.*

The Rule 1. Draw a Line from the Primitive Circle's Center, through one (always the remoteſt) of the two Puncts, to cut the Primitive Circle, and produce it at pleaſure,

2. From the ſaid Punct draw another Line to a Punct in the Primitive Circle, that is 90d. diſtance from the firſt Line.

3. On this laſt Line, and at the Punct in the Primitive Circle, erect a Perpendicular, to cut the firſt Line in the third Punct

4. Through the two given Puncts, and this laſt third Point draw (by *Chap.* 1. *Sect.* 2. *Prob.* 7. *of Practical Geometry,* in *Page* 15) an Arch of Circle, and it's done.

Example. *Plate* 3. *Fig.* 9.

BCDE the Primitive Circle
A the Center thereof —— } given:
F and G two Puncts ——

Through F and G it's required to draw a Great Circle ?

1. Through A and F draw the *Right Circle* BFAD, to cut the PrimitiveCircle in B and D, and continue it further at Pleaſure

2. Lay the Chord of 90d. on the Primitive Circle from B, or from D to E or C, and draw the Line FE, or FC.

3. At E erect EH perpendicular to EF, or (erect CH perpendicular to CF to cut the Diameter BFAD, in H the third Punct.

4. Through F, G and H, draw a Circle, as IFGKH, which cuts the Primitive Circle in I and K, diametrically oppoſite, and it's done.

Prob. 5. *To draw a great Circle perpendicular to, or at Right Angles, with a given great Circle.*

A General Rule. Draw a great Circle through the Pole of the given great Circle, and its perpendicular to it, or it makes a Right Angle with it.

Note, In this Problem are four Caſes.

Prob. 5. Caſe 1. *To draw a Circle Perpendicular to the Primitive Circle,*

The Rule. This is done by drawing a Diameter through the Center of the Primitive Circle; for the Center of the Primitive Circle, being its Pole; all Right Lines drawn through the Center, are Perpendicular Circles to the Primitive Circle.

Example. *Plate* 3. *Fig.* 7.

BCDE the Primitive Circle, and A its Center given; To draw a great Circle perpendicular to it is required.

Through A draw the Right Circle BAD and its perpendicular to the Primitive Circle BCDE, as was required.

Prob. 5.

Prob. 5. Caſe 2. *To draw a Right Circle Perpendicular to a given Right Circle.*

The Rule. This is done by drawing a Diameter at Right Angles, to the given Right Circle: or quartering the Primitive Circle (by *Chapter* 1. *Section* 2. *Problem* 8. *of Practical Geometry*, in Page 15) with two Diameters.

Example. *Plate* 3. *Figure* 7.

BCDE the Primitive } Circle, { and A its *Center* } given
BAD is a Right } { ——— ——— }

To draw a Right Circle perpendicular to the Right Circle BAD is required?

Draw CAE perpendicular to BAD, or from the Chords lay 90d. on the Primitive Circle from B, or from D to C and E; and through A and C, or A and E, draw a Diameter; and it's done.

Prob. 5. Caſe 3. *To draw an Oblique Circle perpendicular to a given Right Circle.*

The Rule. 1. Find the Poles of the given Right Circle, by *Problem* 1. *Caſe* 2. *of Spheric Geometry*, in Page 111.

2. Draw a Circle through thoſe two Poles, and it's done.

Example. *Plate* 3. *Fig.* 7.

BCDE the Primitive Circle }
A the Center thereof —— } given:
BAD is a Right Circle }

To draw an Oblique Circle perpendicular to the Right Circle BAD is required.

1. Take the Chord of 90d. and lay it from B, or D both ways to C and E; which are the two Poles of the Right Circle BAD.

2. With any Diſtance, and one foot on C and E, draw Arches to cut each other in X, the Center of the Oblique Circle CGE, required to be drawn.

Note, If AG be known, or limitted to a certain Diſtance, then it's done by drawing a Circle through the three Puncts C, G and E.

Or. 2. If AG be any known quantity of Degrees, then take the Secant of its Complement, and ſetting one foot on C or E, the other will croſs the given Right Circle, in the Center of the Oblique Circle required to be drawn.

Prob. 5. Caſe 4. *To draw an Oblique Circle perpendicular to a given Oblique Circle.*

The Rule. 1. Find the Poles of the given Oblique Circle, by *Prob.* 1. *Caſe* 3. *of Spheric Geometry,* in Pages 111, and 112.

2. Thro' their Poles draw a Great Circle, which will cut the Primitive Circle diametrically oppoſite, and it's done.

Example. *Plate* 3. *Fig.* 10.

BCDE the Primitive } Circle and { A } its Center given.
BFD an Oblique } { Y }

To draw another Oblique Circle, perpendicular to the Oblique Circle, BFD, is required.

1. Find G, the Pole of the given Oblique Circle BFD, by *Prob.* 1. *Caſe* 3. *of Spheric Geometry,* in *Pages* 111 *and* 112.

2. Through G, draw the Circle HIGK, to cut the Primitive in H and K, and the Oblique Circle BFD in I (ſo that HAK is in a Diameter) and it's done; for then BIH is a Right Angle, and the Cicrles BIFD, and HIGK, are perpendicular to each other.

Note 1. If the Punct I (in the given Oblique Circle) is given, then draw a Circle through I, and the Pole G, by *Prob.* 4. of *Spheric Geometry,* in Page 113, and it's done.

Or, 2. If it be required that the ſaid Oblique Circle ſhall make a certain Angle at the Primitive Circle, then draw a Circle through G, by *Prob.* 3. of *Spheric Geometry,* in Page 113.

Prob. 6. *To lay any quantity of Degrees on any Great Circle.*

In this Problem are three Caſes.

Prob. 1. Caſe 1. *To lay any Quantity of Degrees on the Primitive Circle.*

The Rule. This is done by, or from the Scale of Chords.

Example. *Plate* 3. *Fig.* 8.

BCDE the Primitive Circle, and A its Center given.

To lay 40d 30m. *on the Primitive Circle from* B *is required.*

From the Scale of Chords, take 40d. 30m. and lay it on the Primitive *Circle* from B to C, and it's done.

Prob. 6. Caſe 2. *To lay any Quantity of Degrees on a Right-Circle.*

The Rule. This is done from the Scale of Half Tangents, counting the beginning thereof to be the Center of the Primitive Circle.

Example. *Plate* 3. *Fig.* 11.

BCDE the Primitive Circle, and A its Center } given ;
BAD is a Right Circle ——————————

On the Right Circle BAD, and from A, to lay 40d. 30m. or from B to lay 49d. 30m. is required.

From the Half Tangents, take 40d. 30m. and lay it on BAD from A to *l*; or 49d. 30m. the contrary way of the Half Tangents, laid from B to *l*, and it's done. For A*l* and *l*B together is equal to 90 degrees.

Prob, 6, Caſe 3. *To lay any Quantity of Degrees on an Oblique Circle.*

The Rule 1. Find the Poles of the given Oblique Circle, by Problem 1. Caſe 3. of *Spheric Geometry*, in Pages 111 and 112.

2. Lay the given Quantity of Degrees on the Primitive Circle, by *Caſe* 1. of this Problem.

3. Reduce it from the Primitive Circle to the given Oblique Circle by the help of its Pole, and it's done.

Example. *Plate* 3. *Figure* 11.

BCDE the Primitive } Circle, and { A } its *Center* given ;
BFD an Oblique — } Circle, and { Y } its *Center* given ;

On the Oblique Circle BFD (from B) to lay 51d. 30m. is required ?

1. By Y and A, draw the Diameter CAE, and ſind G the Pole of the Oblique Circle, by *Prob.* 1. *Caſe* 3. in *Page* 111.

2. From the Scale of *Chords*, take 51d. 30m. and lay it on the Primitive Circle, from B to H.

3. Lay a Scale on G and H, to cut the Oblique Circle BFD in I, then is BI on the Oblique Circle equal to 51d. 30m. as required.

Prob. 7 *To meaſure any Part of a Great Circle.*

In this Problem are three *Caſes*, which are but the Converſe of thoſe in the laſt Problem.

Prob. 7. Caſe 1. *To meaſure any Part of the Primitive Circle.*

The Rule. Take the part required to be meaſured, and lay it on the *Scale of Chords*, and it ſheweth how much it is.

Example. *Plate* 4. *Fig*, 8.

BCDE the Primitive Circle, and A it's Center given ;

To meaſure BC, *a Part of the Primitive Circle, is required.*

Take the Extent BC in the Compaſſes, and lay it on the *Chords*, which will ſhew how many Degrees BC doth meaſure

Prob. 7. Caſe 2. *To meaſure any Part of a Right Circle.*

The Rule 1. If the Part to be meaſured lieth next the Center of the Primitive Circle, then its meaſured on the *Scale* of *Half Tangents*, from the Braſs Center-pin at the Beginning thereof.

2 When the Part to be meaſured lieth next the Primitive Circle, then it's meaſured on the Scale of *Half Tangents*, from 90 deg. counting 80d. to be 10d. 70 to be 20, 60 to be 30, *&c.*

Example. *Plate* 3. *Fig.* 7.

BCDE the Primitive Circle, and A its Center }
BAD a Right Circle ———————————— } given;

To meaſure A l, or B l, on the Right Circle BAD, is required?

1. Take *A l*, and lay it on the Scale of *Half Tangents* from the Braſs Center-pin (at the Beginning of it) which will ſhew how many Degrees it is. Or,

2. Take *B l*, and lay it on the Scale of *Half Tangents* from 90d. backward, counting 80d. to be 10, and 70 to be 20, *&c.* ſo will it ſhew how many Degrees *B l* is. And.

Note; That *A l*, and *B l*, will make together juſt 90d. they being Complements to each other.

Prob. 7. Caſe 3. *To meaſure any Part of an Oblique Circle.*

The Rule 1. Find the Poles of the given Oblique Circle, by *Prob.* 1. *Caſe* 3. of *Spheric Geometry*, in Pages 111 and 112.

2. Lay a Scale on either of the ſaid Poles and the Part deſired to be meaſured, and reduce it to the Primitive Circle.

3. It being reduced to the Primitive Circle, its meaſured on the *Scale of Chords*, as before in Caſe 1. of this Problem.

Example. *Plate* 3. *Fig.* 11.

BCDE *the Primitive* } *Circle, and* { A } its *Center given*;
BIFD *an Oblique* } { Y }

To meaſure B I, and F I, on the Oblique Circle BIFD, is required.

1. Find G the Poles of the Oblique Circle BIFD, by *Prob.* 1. *Caſe* 3. of *Spheric Geometry*, in *Pages* 111, and 112.

2, Lay a Scale on G and I, to cut the Primitive Circle in H.

3. Then EH meaſured on the Scale of *Chords*, is the meaſure,

of B I; and EH on the ſame Scale of Chords is the ure of F I.

Prob. 8. *To meaſure any Spheric Angle.*

In this Problem are four Caſes, and this is,

General Rule. A Spheric Angle is meaſured by the Arch reat Circle, intercepted between the two containing Sides, ngular Punct being the Pole of that Circle. Or the Di- e of the Poles of the containing Sides, is equal to the ure of the contained Angle.

), 8, Caſe 1. *To meaſure an Angle, when its Angular Punct is the Center of the Primitive Circle.*

he Rule. Such an Angle is meaſured (like a Plain Angle) the Primitive Circle, by a *Scale of Chords.*

Example. *Plate 3. Fig 8.*

DE the Primitive Circle, A its Center, and the Angular punct given: to meaſure the Angle BAC is required.

'ake B C, and meaſure it on the *Scale of Chords*, ſhews Angle how much it is.

b. 8. Caſe 3. *To meaſure an Angle, when its Angular Punct is at the Primitive Circle.*

he Rule. 1. Find the Poles of the two containing Sides, by . 1. *of Spheric Geometry*, in Pages 111. and 112.

. The Diſtance of thoſe two Poles, is the meaſure of the ired Angle.

ote 1. When the two Poles are in one Diameter or Right cle, it's meaſured on the Scale of Half Tangents.

. When they are not in one Diameter, then reduce them he Primitive Circle, by laying a Scale on the Angular punct, the ſaid two Poles which Diſtance being meaſured, on the le of *Chords*, is the meaſure of the required Angle.

Example, *Plate 3. Fig 8.*

$$\left.\begin{array}{l}\text{BCDE } \textit{the Primitive}\\ \text{BGFD } \textit{an Oblique}\end{array}\right\}\textit{Circle, and}\left\{\begin{array}{c}\text{A}\\ \text{Y}\end{array}\right\}\textit{its Center}\text{ given.}$$

To meaſure the Angle EDF *equal to the Angle* EBF *is required.*

1. Through A and Y, draw a Diameter to cut the Primi- ve Circle in H and I, and the Oblique Circle in G.

2. In the Diameter IAH, find K, the Pole of the Oblique ircle BGFD.

3. The Diſtance A K, or G I, meaſured on the Scale of Half-

Prob. 7. Caſe 2. *To meaſure any Part of a Right Circl*

The Rule 1. If the Part to be meaſured lieth next th ter of the Primitive Circle, then its meaſured on the S *Half Tangents*, from the Braſs Center-pin at the Beg thereof.

2 When the Part to be meaſured lieth next the tive Circle, then it's meaſured on the Scale of *Half Ta* from 90 deg. counting 80d. to be 10d. 70 to be 20, 60 30, &c.

Example. *Plate* 3. *Fig.* 7.

BCDE the Primitive Circle, and A its Center }
BAD a Right Circle ——— ——— —— } given

To meaſure A l, or B l, on the Right Circle BAD, is required?

1. Take *A l*, and lay it on the Scale of *Half Tan* from the Braſs Center-pin (at the Beginning of it) which ſhew how many Degrees it is. Or,

2. Take *B l*, and lay it on the Scale of *Half Tangents* 90d. backward, counting 80d. to be 10, and 70 to b &c. ſo will it ſhew how many Degrees *B l* is. And.

Note; That *A l*, and *B l*, will make together juſt 90d being Complements to each other.

Prob. 7. Caſe 3. *To meaſure any Part of an Oblique Cir*

The Rule 1. Find the Poles of the given Oblique Circ *Prob.* 1. *Caſe* 3. of *Spheric Geometry*, in Pages 111 and 11

2. Lay a Scale on either of the ſaid Poles and the Par red to be meaſured, and reduce it to the Primitive Circle

3. It being reduced to the Primitive Circle, its mea on the *Scale of Chords*, as before in Caſe 1. of this Proble

Example. *Plate* 3. *Fig.* 11.

BCDE *the Primitive* } *Circle, and* { A } its *Center given*;
BIFD *an Oblique* } { Y }

To meaſure B I, and F I, on the Oblique Circle BIFD, is requi

1. Find G the Poles of the Oblique Circle BIFD, by *Pr* *Caſe* 3. of *Spheric Geometry*, in *Pages* 111, and 112.

2, Lay a Scale on G and I, to cut the Primitive Circ H.

3. Then EH meaſured on the Scale of *Chords*, is the

ſure of B I; and EH on the ſame Scale of Chords is the meaſure of F I.

Prob. 8. *To meaſure any Spheric Angle.*

In this Problem are four Caſes, and this is,

A General Rule. A Spheric Angle is meaſured by the Arch of a great Circle, intercepted between the two containing Sides, the Angular Punct being the Pole of that Circle. Or the Diſtance of the Poles of the containing Sides, is equal to the meaſure of the contained Angle.

Prob, 8, Caſe 1. *To meaſure an Angle, when its Angular Punct is the Center of the Primitive Circle.*

The Rule. Such an Angle is meaſured (like a Plain Angle) on the Primitive Circle, by a *Scale of Chords.*

Example. *Plate* 3. *Fig* 8.

BCDE the Primitive Circle, A its Center, and the Angular punct given: to meaſure the Angle BAC is required.

Take B C, and meaſure it on the *Scale of Chords*, ſhews the Angle how much it is.

Prob. 8. Caſe 3. *To meaſure an Angle, when its Angular Punct is at the Primitive Circle.*

The Rule. 1. Find the Poles of the two containing Sides, by *Prob. 1. of Spheric Geometry*, in Pages 111. and 112.

2. The Diſtance of thoſe two Poles, is the meaſure of the required Angle.

Note 1. When the two Poles are in one Diameter or Right Circle, it's meaſured on the Scale of Half Tangents.

2. When they are not in one Diameter, then reduce them to the Primitive Circle, by laying a Scale on the Angular punct, and the ſaid two Poles which Diſtance being meaſured, on the Scale of *Chords*, is the meaſure of the required Angle.

Example, *Plate* 3. *Fig* 8.

$$\left.\begin{array}{l}\text{BCDE \textit{the Primitive}}\\ \text{BGFD \textit{an Oblique}}\end{array}\right\}\textit{Circle, and}\left\{\begin{array}{c}\text{A}\\ \text{Y}\end{array}\right\}\textit{its Center}\text{ given.}$$

To meaſure the Angle EDF *equal to the Angle* EBF *is required.*

1. Through A and Y, draw a Diameter to cut the Primitive Circle in H and I, and the Oblique Circle in G.

2. In the Diameter IAH, find K, the Pole of the Oblique Circle BGFD.

3. The Diſtance A K, or G I, meaſured on the Scale of

Half Tangents (the latter the contrary way on that Scale from 90d.) ſheweth how much the Angle EDF or EBF is.

Prob. 8. Caſe 3. *To meaſure an Angle when its Angular Punct is not in the Center of, nor at the Primitive Circle.*

The Rule is this. 1. Find the two Poles of the two containing Sides, by Problem 1, in Pages 111 and 112.

2. Reduce thoſe two Poles to the *Primitive Circle*, then meaſure the Diſtance of them on a *Scale of Chords*, and it's done.

Note, Reduce, is to lay a Scale on the Angular punct (required to be meaſured) and the ſaid two Poles to cut the *Primitive Circle.*

Example. *Plate* 3. *Fig.* 8.

BCDE *the Primitive*
BGFD *an Oblique*— *Circle, and* A Y *its Center* ——
CAFE *a Right* — — *cuts the Oblique in* F. given

To meaſure the Angle DFE, *or* BFE *is required?*

1. Through A and Y draw the Diameter IAH, and in it find K the Pole of the Oblique Circle BGFD; as before in the laſt Caſe.

2. Find L the Pole of the Right Circle CAFE, by *Prob.* 1. *Caſe* 2. *of Spheric Geometry*, in *Page* 111.

3. Reduce K to the Primitive Circle (by laying a Scale on F, and K, to cut the *Primitive Circle*) and it's M: Then LM meaſured on the *Chords*, ſheweth how much the Angle DFE, or BFE is; one Acute and the other Obtuſe.

Prob. 8. Caſe 4. *To meaſure an Angle, when the containing Sides are both Oblique Circles.*

Example. *Plate* 3. *Fig.* 12.

BCDE *the Primitive*
CHFE *an Oblique* Circle, and A Y X its *Center given*;
BGFD *an Oblique*

To meaſure the Angle DFE, *or* BFE *is required?*

1. By A and Y, and A and X, draw two Diameters; in them find I and K, the two Poles of the containing Sides, by *Prob.* 1. *Caſe* 3. *of Spheric Geometry*, in *Pages* 111 *and* 112.

2. Reduce thoſe two Poles I and K, (by laying a Scale on the Angular punct F, and them) to cut the Primitive Circle in L and M; which being meaſured on the *Chords* ſheweth how much the Angle DFE, or BFE is; one Acute, the other Obtuſe.

Prob. 9. *To draw a Parallel Circle.*

Definition. A Parallel Circle, or leſſer Circle, cutteth the Sphere into two unequal Parts, and lieth Parallel to a Great Circle. In this Problem are three *Caſes.*

Prob. 9. Caſe 1. *To draw a Parallel Circle parallel to the Primitive Circle, at any given Diſtance from it, or from its Pole.*

The Rule. With the Half Tangent of its Diſtance from the Pole, and one Foot on the Center of the Primitive Circle, draw a Circle, and it's done.

Example. *Plate* 3. *Fig.* 7.

BCDE the Primitive Circle, A its Center given ; to draw a Circle parallel to BCDE, at 30d. diſtance from it, is required?

With the Half Tangent of 60d. (the Complement of 30d. and) its Diſtance from the Pole of the Primitive Circle, ſet one Foot in A (the Center and Pole of the Primitive) and deſcribe the Circle *l m n o*, which is parallel as required.

Prob. 9. Caſe 2. *To draw a Circle parallel to a Right Circle.*

The Rule 1. From the Chords lay the Parallel's Diſtance from the Right Circle ; or the Complement thereof, from the Pole of the Right Circle both ways, and note thoſe two Marks, on the Primitive Circle.

2. With the Tangent of the Parallel's Diſtance from the Pole of the Right Circle, and one Foot on each of thoſe two Marks, deſcribe Arches, to cut each other in the Center of the Parallel Circle required to be drawn.

Example. *Plate* 3. *Fig.* 7.

BCDE the Primitive Circle, and A its Center }
BAD is a Right Circle——————————— } given.

To draw a Circle parallel to B A D, *at* 40d. *Diſtance from it, or* 50d. *Diſtance from* C, *its Pole is required* ?

1. Lay 40d. from B to *p*, and from D to *q* ; or lay it's Complement 50d. from C both ways to the ſaid *p* and *q*.

With the Tangent of 50d. and one Foot on $\left\{\begin{matrix} p \\ q \end{matrix}\right\}$ make the Arch *y* ; which croſſing at *y*, is the Center of the Parallel Circle *p r q* required to be drawn.

Prob. 9. Caſe 3. To draw a Circle Parallel to an Oblique Circle.

The Rule. 1. Find the Pole of the given Oblique Circle, by *Prob.* 1. *Caſe* 3. in *Pages* 111 and 112, which reduce to the Primitive Circle, and therefrom lay the Parallels Diſtance from the Pole both ways, which being reduced to the Right Circle, is the Diameter of the Parallel Circle.

2. Find the middle of thoſe two marks which is the Center of the Parallel paſſing through thoſe Marks, and it's done.

Example. *Plate* 3. *Fig* 11.

$\left.\begin{array}{l}\text{BCDE the Primitive}\\ \text{BIFD an Oblique}\end{array}\right\}$ Circle and $\left\{\begin{array}{c}\text{A}\\ \text{Y}\end{array}\right\}$ its Center given:

To draw a Circle parallel to BIFD, at 40d. diſtance from it, or 50d. diſtance from its Pole is required.

1. Find G the Pole of the given Oblique Circle BIFD, by *Prob* 1. *Caſe* 3. *of Spheric Geometry*, in *Pages* 111 *and* 112.

2. Meaſure AG on the Half Tangents, and ſuppoſe it to be 30d. then add 50 to it, and ſubtract it from 50; the Sum 80d. lay from A to *k*; and the Difference 20d. lay from A to *l*. Or thus, Reduce G to the Primitive Circle, and from it lay 50d. both ways, which reduce to the Right Circle, gives the ſame points *k* and *l*.

3. Find *m* the middle between *k* and *l*, and on *m* as a Center draw a Circle to paſs through *k* and *l*, which is the Parallel Circle required to be drawn.

Thus much for *Problems* neceſſary for the making and meaſuring Spheric Triangles; which I adviſe the Learner to acquaint himſelf with, and then the following Applications will be the better underſtood.

Section II. *The uſe of the Nine preceeding Problems, in making any Spheric Triangle, and meaſuring its Parts; or the Doctrine of Spheric Triangles Geometrical.*

Definition 1. A Sphere or Globe, is a round Body made by the moving a Semicircle about its own Diameter, till the Motion end where it firſt began. The Semicircles Diameter, is the Axis, or Diameter of the Sphere; in the middle of which is a Punct, called the Center; from whence all Right Lines drawn to the Surface, or outſide of the Sphere are equal.

2. A Spheric Triangle, is deſcribed on the Surface of the Sphere; whoſe Sides are the Arches of three great Circles, mu-

tually

Plate 3.

Fig. I.

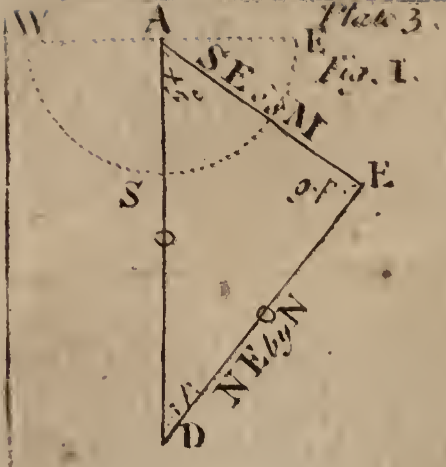


Fig: II.

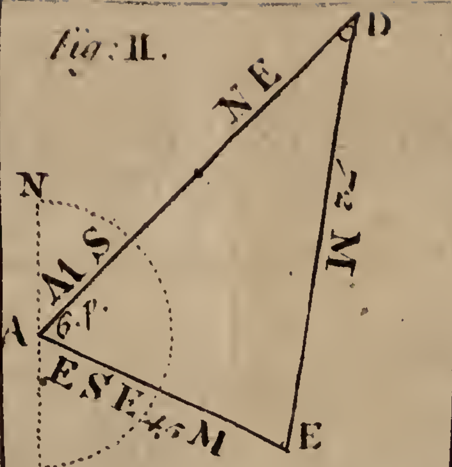


Fig: III.

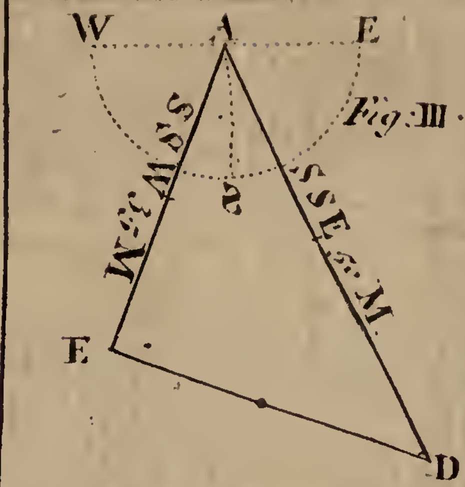
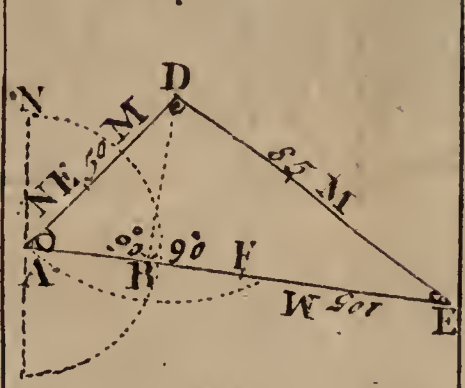


Fig: IV



This ſhould be Fig:15 in Plate:2 & belongs to page:67:

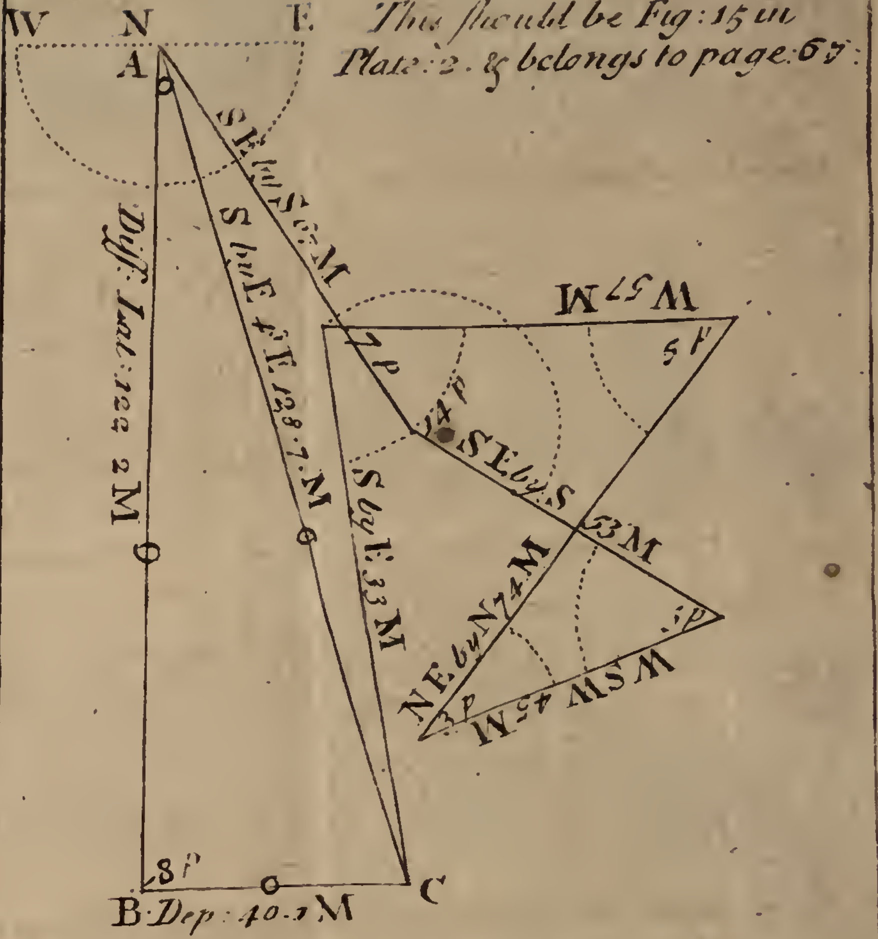


Fig: V

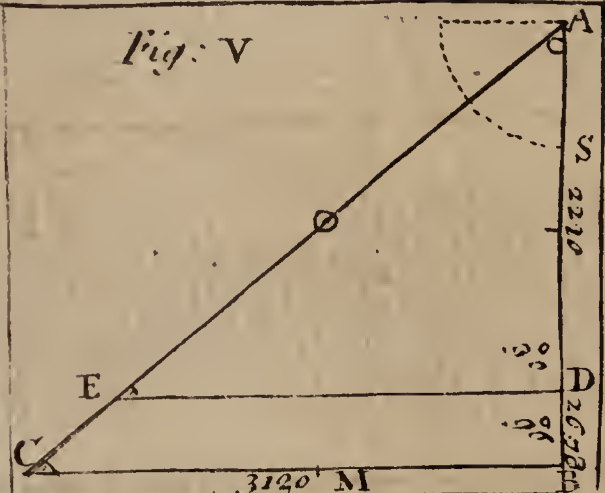


Fig: VI

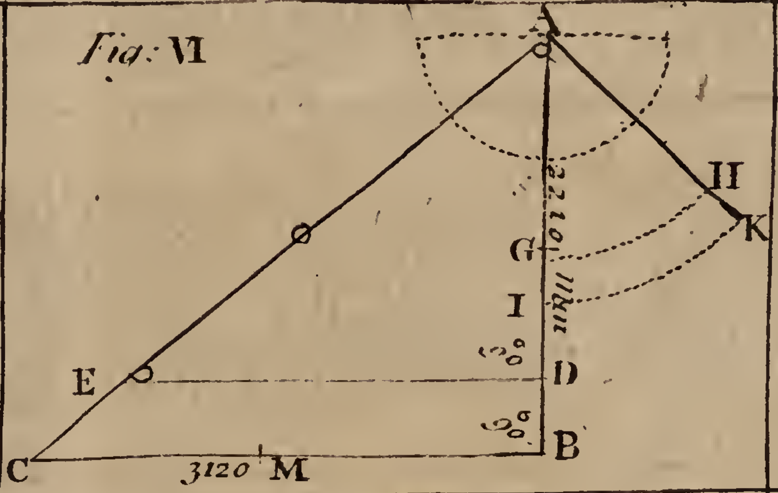


Fig VII

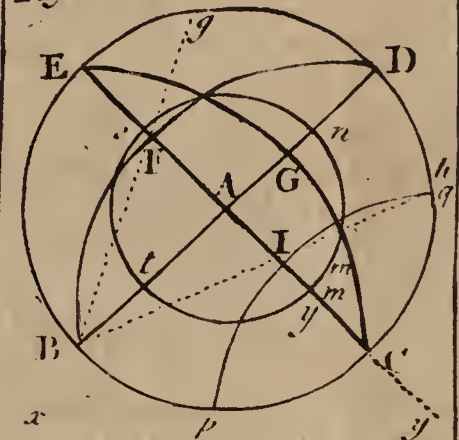


Fig VIII

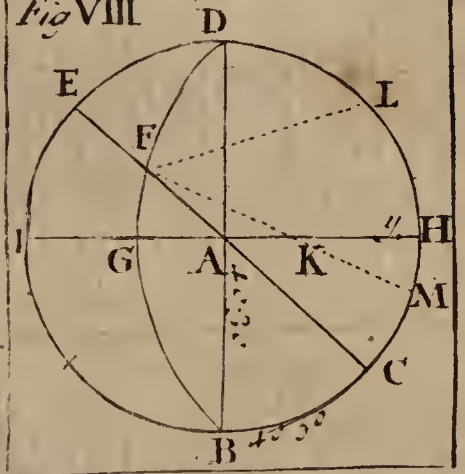


Fig IX

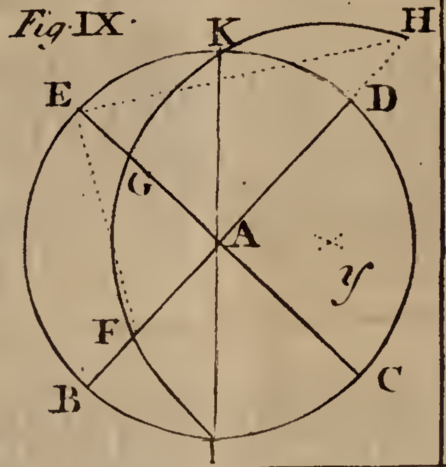


Fig: X.

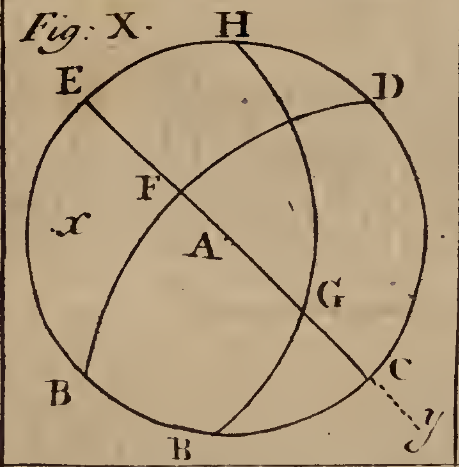


Fig. XI

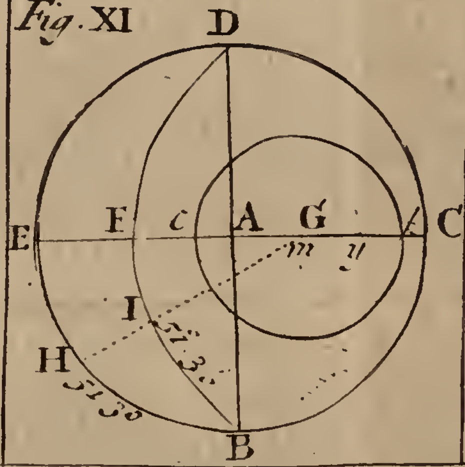
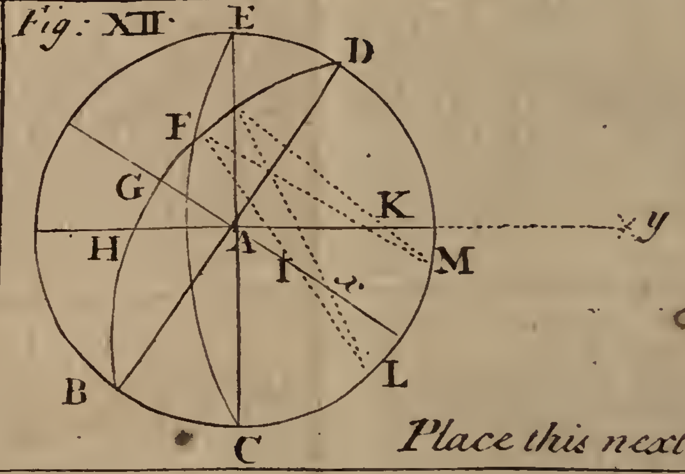


Fig: XII



Place this next Page 129

tually interſecting each other; and is either Quadrantal, Rectangular; or Obliquangular.

3. { A Quadrantal
A Rectangular
An Obliquangular } Triangle hath { one Side
one Angle } 90d.
{ noSide aQuadrant or 90d. nor any Angle 90d.

Note 1. In every Spheric Triangle, each Side is leſs than 180 Degrees.

2. The Sum of any two Sides, is greater than the Third Side.

3. The Three Sides added together, their Sumis leſs than 360 Degrees.

4. The Sum of the Three Angles, is ever more than 180d. but leſs than 540 Degrees.

Prob 10. *The Hypotenuſe and one Leg given; to make a Rectangular Spheric Triangle.*

Note, To make a Rectangle Spheric Triangle, two Things, beſides the Rectangle muſt be given.

Example; *Plate* 4. *Fig.* 1.

The { Hypotenuſe *AC* 54d. 25m.
Leg *BC* —— 23d. 30m. } given:

With them to make a Rectangle Spheric Triangle is required.

1. Draw the Primitive Circle with a Chord of 60d. a Sine of 90d. or with a half Tangent of 90d. and quarter it, which muſt be done in every *Problem.*

Then conſider whether one of the Oblique Angles ſhall be at the Primitive Circle, or at its Center.

Firſt, If at the Center of the Primitive Circle, then,

1 Draw (by *Prob.* 9. *Caſe* 1. of *Spheric Geometry*) a Circle Parallel to the Primitive, at 54d. 25m. (the given Hypotenuſe) diſtance from its Pole; that is, with the Half Tangent of 54d. 25m. and one Foot on A) the Center of the Primitive Circle) deſcribe a Circle.

2. Then (by the 2*d Caſe* of the aforeſaid *Prob.*) draw a Circle Parallel to a Right Circle at 23d. 30m. (the given Leg) diſtance from it: Theſe two Parallel Circles cut each other in C.

2. Through A and C, draw a Great Circle, which in this Caſe, is a Right Circle; that is, a Diameter: And from C, (*by Prob,* 5. *Caſe* 3. *of Spheric Geometry, in Page* 115) draw

a

a Great Circle perpendicular, or at Right-Angles to A B; which in this Caſe will be an Oblique Circle, and it's done. Or,

Secondly, To make the Triangle, that one of its Oblique Angles may be at the Primitive Circle.

1. The Circle being deſcribed, and quartered as before directed. Then,

2. Draw (by *Prob.* 9. of *Spheric Geometry*) a Circle parrallel to a Right Circle, at 54d. 25m. diſtance from A its Pole.

3. And (by the foreſaid *Problem* draw a Circle parallel to the Primitive Circle, at 23d. 30m. diſtance from it, to cut the former Parallel Circle in C.

4. Then through A and C draw a Great Circle; which in this Caſe will be an Oblique Circle: and from C (by *Prob.* 5. *Caſe* 1. *of Spheric Geometry*, in *Page* 114) draw a Great Circle pependicular to AB; which in this Caſe will be a Right Circle, and it's done.

To meaſure the Things required.

The { Leg AB ——————— } is meaſured { 7. *Page* 117.
The { Angles BAC and ACB } by *Prob.* { 8. *Page* 118, 119.

Prob. 11. *The Hypothenuſe and one Angle given; to make a Triangle.*

Example. *Plate* 4. *Fig* 2.

The { Hypotenuſe AC 54d. 25m. } given:
The { Angle BAC 29d. 30m. } given:

With them to make a Rectangle Spheric Triangle, is required.

Firſt, To make the Triangle, that the given Angle BAC may be at the Primitive Circle's Center.

1. Having deſcribed the Primitive Circle, and quartered it, as before directed in *Prob.* 10. make the Angle BAC equal to 29d. 30m. (by *Prob.* 2. *Caſe* 1. in *Page* 112 of *Spheric Geometry*;) That is, from the Scale of Chords, lay 29d. 30m. on the Primitive Circle, and therefrom draw a Line thro' A the Center of the Primitive Circle.

2. Make AC equal to 54d. 25m. by Prob. 6. Caſe 2. in Page 116 of *Spheric Geometry*; that is, from the Scale of Half Tangents, lay 54d. 25m. from A to C.

3. By *Prob.* 5. *Caſe* 3. in *Page* 115, draw a Circle from C

Perpendicular unto A B, to cut the Right Circle A B in B ; which in this *Caſe* is an Oblique *Circle*, and its done.

Secondly, To make the Triangle ſo, that the given Angle may be at the Primitive *Circle*.

1. After the Primitive *Circle* is made, and quarter'd as before, let A be one of thoſe Marks or Quarters : Then by *Prob.* 2. *Caſe* 2. in *Page* 112.) make the Angle at A equal to 29d. 30m. by drawing an Oblique *Circle* with the Secant of the given Angle, as is the Oblique *Circle A C.*

2. Then by *Prob. 6. Caſe* 3. in *Page* 117, lay 54d. 25m. on the Oblique *Circle* from *A* to *C.* Or, draw by *Prob. 9. Caſe* 2. in Page 121.) a *Circle* parallel to a Right *Circle* at 54d. 25m. diſtance from A it's Pole, to cut the Oblique *Circle AC* in *C.*

3. By *Prob.* 5. *Caſe* 1. in Page 114, draw a *Circle* from *C*, perpendicular to the Primitive *Circle* A B ; to cut AB in B ; which in this *Caſe* is a Right *Circle*, and it's done.

To meaſure the Things required.

The { Legs *A B* and *BC* } is meaſured by *Prob.* { 7. Page 117.
{ Angle *ACB*—— } { 8. Page 119.

Prob. 12. *A Leg and its adjacent Angle given ; to make a Triangle*

Example. *Plate* 4. *Fig.* 3.

The { Leg *A B* —— 50d. 30m. } given :
{ Angle *B A C* 29d. 30m. }

With them to make a Rectangle Spherical Triangle is requir'd.

Firſt, To make the Triangle, that the given Angle (*BAC*) may be at the Primitive *Circle's* Center.

1. The Primitive *Circle* being deſcribed, and quartered as before, and A placed at it's *Center* ; then (by *Prob.* 2. *Caſe* 1. in Page 112. of *Spheric Geometry*) make the Angle *BA C* equal to 29d. 30m by drawing the Right *Circle A C.*

2. By *Prob. 6. Caſe* 2. in *Page* 116, make *AB* equal to 50d. 30m. that is, from the Scale of Half-Tangents, lay 50d. 30m. on the Right Circle from *A* to *B*.

3. By *Prob.* 5. *Caſe* 3. in *Page* 115, draw from B an Oblique *Circle*, *B C*, perpendicular to the Right *Circle* A B, to cut the Right *Circle A C* in *C*, and it's done. Or thus,

From the Scale of Secants, take 39d. 30m. (the Complement of AB 50d. 30m.) ſetting one Foot in B, the other Foot marks out (on the Right *Circle* AB extended) the Center of the Oblique *Circle B C*, which concludes the Triangle.

Secondly, To make the Triangle ſo, that the given Angle may be at the Primitive *Circle*.

1. A being on or at the Primitive Circle, then (by *Prob.* 2 *Caſe* 2. *in Page* 112) make the Angle BAC equal to 29d 30m. by drawing the Oblique Circle AC, with the Secant thereof.

2. By *Prob.* 6. *Caſe* 1. in *Page* 116. make AB (on the Primitive Circle) equal to 50d. 30m. by laying the Chord of it, from A to B.

3. By *Prob.* 5. *Caſe* 1. in *Page* 114, draw a great Circle from B, perpendicular to AB. as the Right Circle BC, to cut the Oblique Circle AC in C, and it's done.

To meaſure the things required.

The { Leg BC, and Hypot. AC / Angle ACB ——— } is meaſured by *Pr.* { 7 / 8 } in Pages 117, 118 and 119.

Prob. 13. *A Leg and its oppoſite Angle given; to make a Triangle.*

Example. *Plate* 4. *Fig.* 2.

The { Leg BC —— 23d. 30m. / Angle BAC 29d. 30m. } given:

With them to make a Rectangle Spheric Triangle, is required.

Firſt; to make the Triangle, with the given Angle at the Primitive Circle's Center.

1. The Primitive Circle drawn, *&c.* as before, and A at its Center, then (by *Prob.* 2. *Caſe* 1. in *Page* 112) make the Angle BAC equal to 29d. 30m. by drawing two Right Circles AB, and AC.

2. Draw (by *Prob.* 9. *Caſe* 2. in *Page* 121.) a Parallel Circle, parallel to the Right Circle AB, at 23d. 30m. diſtance from it, to cut the Circle AC in C.

3. From C (by *Prob.* 5. *Caſe* 3. *in Page* 115) draw an Oblique Circle BC, perpendicular to the Right Circle AB, to cut AB in B; and it's done.

Secondly, To make the Triangle, that the given Angle may be at the Primitive Circle.

1. A being at the Primitive Circle, than (by *Prob.* 2. *Caſe* 2. in *Page* 112) make the Angle BAC equal to 29d. 30m, by drawing the Oblique Circle AC, with the Secant thereof.

2. By *Prob.* 9. *Caſe* 1. in *Page* 121, draw a Parallel Circle, parallel to the Primitive Circle AB, at 23d. 30m. diſtance from it, to cut the Oblique Circle AC in C. Or thus, with the Half Tangent of 66d. 30m. (the Complement of 23d. 30m.) and one Foot in the Center of the Primitive Circle, with the other cut the Oblique Circle in C.

3. From C (by *Prob.* 5. *Caſe* 1. in Page 114) draw a Right

Circle *BC*, perpendicular to the Primitive Circle *AB* to cut *AB* in *B*, and it's done.

To meaſure the Things required.

$$\text{The}\left\{\begin{array}{l}\text{Hypot. }AC\text{ and Leg }AB\\ \text{Angle }ACB\text{ ———— ——}\end{array}\right\}\text{is meaſured by Prob.}\left\{\begin{array}{l}7.\\ 8.\end{array}\right.$$

in Pages 117, 118 and 119.

Prob. 14. *Both Legs given to make a Triangle*

Example. *Plate* 4. *Fig.* 5.

$$\text{The Leg}\left\{\begin{array}{l}\text{AB 50d. 30m.}\\ \text{BC 23d. 30m.}\end{array}\right\}\text{given:}$$

With them to make a Rectangle Spheric Triangle; is required.

Firſt, To make the Triangle, that one of the Oblique Angles may be at the Primitive Circles Center.

1. A being at the Center of the *Primitive Circle*, draw the *Right Circle* A B, and thereon (by *Prob.* 6. *Caſe* 2. in *Page* 116) make AB equal to 50d. 30m. by laying the *Half-Tangent* thereof, from A to B.

2. From B (by *Prob.* 5. *Caſe* 3. in *Page* 115) draw an *Oblique Circle* BC Perpendicular to A B. Or thus.

With the Secant of 39d. 30m. (the Complement of 50d. 30m.) and one Foot on B, the other Foot marks out (in the Right Circle *AB* extended) the Center of the *Oblique Circle BC*.

3. Draw (by *Prob.* 9. *Caſe* 2. *in Page* 121.) a Parallel Circle Parallel to the Right Circle *AB*, at 23d. 30m. Diſtance from it to cut the Oblique Circle *BC* in *C*. Or thus,

By *Prob.* 6. *Caſe* 3. *in Page* 117. Lay 23d. 30m on the Oblique Circle, from *B* to *C*.

4 Through *A* and *C* draw a Great Circle; which in this *Caſe*, is a Right Circle, and it's done

Secondly, To make the Triangle, that one of the Oblique Angles may be at the Primitive Circle.

1. By *Prob.* 6. *Caſe* 1. in *Page* 116 make *AB* equal to 50d. 30m. by laying the *Chord* thereof on the Primitive Circle from *A* to *B*.

2. From B (by *Prob.* 5. *Caſe* 1. in Page 114) draw a Great *Circle* perpendicular to the Primitive *Circle* (which in this *Caſe* is a Right Circle) as B C.

3. Draw (by *Prob.* 9. *Caſe* 1. in *Page* 121.) a Parallel Circle, parallel to the Primitive Circle *AB*, at 23d. 30m. diſtance from it, to cut the Right Circle BC in C. Or thus,

From the Scale of Half Tangents, lay 66d. 30m. (the *Complement* of 23d. 30m.) from the *Center* of the Primitive *Circle*, on the Right *Circle* to *C*,

4. Through A and C, draw a Great Circle; which in this Caſe is an Oblique Circle, and it's done.

To meaſure the Things required.

The { Hipotenuſe AC————
Angles BAC, and ACB } is meaſured by *Prob.* { 7. 8. } in
Pages 117, 118, and 119.

Prob. 15. *Both the Angles given; to make a Triangle.*

Example. *Plate* 4. *Fig.* 6.

The Angle { BAC 29d. 30m
ACB 71d. 56m. } given:

With them to make a Rectangle Spheric Triangle, is requir'd

1. By *Prob.* 2. *Caſe* 2. in *Page* 112, make the Angle BAC equal to 29d. 30m. by drawing the Oblique Circle AB, with the Secant thereof.

2. Find I, the Pole of the Oblique Circle AB; by *Prob.* 1. *Caſe* 3. *in Pages* 111 *and* 112.

3. Through I (by *Page* 3. in *Page* 113.) draw an Oblique Circle IBC, that the Angle A C B may be 71d. 56m. which will cut the Oblique Circle AB, in B the Rectangle, and the Primitive Circle in C, and ſo conclude the Rectangle Triangle ABC required to be made.

To meaſure the Things required.

The Hypotenuſe AC, and Legs AB and BC, are meaſured by *Prob.* 7. *of Spheric Geometry*, in *Pages* 117 and 118.

Thus all the Caſes of Rectangle Spheric Triangles may be deſcribed, and reſolved by the laſt Six Problems. In like manner the Caſes of Oblique Triangles may be Geometrically ſolved by the Six following.

Prob. 16. *Two Sides and an Angle oppoſite given; to make an Oblique Spheric Triangle.*

Note: To make an Oblique Spheric Triangle, three Things muſt be given.

Note alſo, The Angle oppoſite to the other given Side ought to be foreknown, whether Acute or Obtuſe: otherwiſe two ſeveral Triangles may be made from the given Things.

Example. *Plate* 4. *Fig.* 7.

The { Side —— AC 34d. 07m
Side —— AD 65d. 20m
Angle ADC 27d. 30m } given:

With them to make a Triangle (ſo that the Angle ACD may be Obtuſe) is required.

1. On the Primitive Circle make AD (the given Side joining to the given Angle) equal to 65d. 20m. by *Prob. 5 Caſe* 1. *of Spheric Geometry.*

2. By *Prob.* 2. *Caſe* 2. make the Angle ADC equal to 27d. 30m. by drawing the *Oblique Circle* DC, with the *Secant* thereof.

3. Draw (by *Prob.* 9. *Caſe* 2.) a Parallel Circle at 34d. 07m. diſtance from A, to cut the Oblique Circle DC, in C.

4. Through A and C draw a great Circle, and its done.

To meaſure the Things required.

The { *Angles* CAD, *and* ACD } is meaſured by *Prob.* { 8.
{ *Side* —— CD, —— } { 7.

Prob. 17. *Two Angles and one Side oppoſite given: to make an Oblique Spheric Triangle.*

Example. *Plate* 4. *Fig.* 8.

The { Angle CAD 30d. 48m.
Angle ADC 27d. 30m.
Side — CD 38d. 28m. } given:

With them to make a Triangle (ſo that the Side AC *may be leſs than 90d.) is required.*

1. By *Prob.* 2. *Caſe* 2. make the Angle ADC equal to 27d. 30m. (always the Angle joining to the given Side) by drawing the Oblique Circle DC with the Secant of it.

2. Draw (by *Prob* 9. *Caſe* 2.) a Parallel Circle at 38d. 28m. diſtance from D, to cut the Oblique Circle DC, in C.

3. Then through C (by *Prob.* 3.) draw a great Circle to make an Angle at the Primitive Circle, that may be equal to 30d. 48m. as is the Oblique Circle CA, and it's done.

To meaſure the Things required.

The { Sides AC and AD } is meaſured by *Prob.* { 7.
{ Angle ACD — — } { 8.

Note. In theſe two laſt Problems, the three given Things without the Quality of a Fourth, are not ſufficient to make a Triangle: And the Quality of the Fourth is not always diſcoverable by the given Things; therefore they are called *Doubtleſs Caſes.*

Prob 18. *Two Sides, and one Angle between them given; to make an Oblique Spheric Triangle.*

Example, *Plate* 4. *Fig.* 9.

$$\text{The}\left\{\begin{array}{l}\text{Side —— AC 34d. 06m.}\\ \text{Side —— AD 65d. 20m.}\\ \text{Angle CAD 30d, 46m.}\end{array}\right\}\text{given.}$$

With them to make a Triangle is required?

1. By *Prob.* 2 *Caſe* 2. make the Angle CAD equal to 30d. 46m. by drawing the *Oblique Circle* AD with the *Secant* thereof.

2. Make AC on the Primitive Circle equal to 34d. 06m. and AD on the Oblique Circle equal to 65d. 20m. by *Prob.* 6. *Caſe* 1 and 3.

3. Through C and D draw a Great Circle, and it's done.

To meaſure the Things required.

$$\text{The}\left\{\begin{array}{l}\text{Side —— CD —— ——}\\ \text{Angles ACD, and ADC}\end{array}\right\}\text{is meaſured by }\textit{Prob.}\left\{\begin{array}{l}7.\\ 8.\end{array}\right.$$

Prob. 19. *Two Angles and one ſide between them given; to make an Oblique Triangle,*

Example. *Plate* 4. *Fig.* 10.

$$\text{The}\left\{\begin{array}{l}\text{Angle ACD 131d. 34m.}\\ \text{Angle ADC 27d. 30m.}\\ \text{Side CD 38d. 28m.}\end{array}\right\}\text{given:}$$

With them to make a Triangle is required?

1. On the Primitive Circle make CD equal to 38d. 28m. the given Side, by *Prob.* 6. *Caſe* 1.

2. At C (by *Prob.* 2. *Caſe* 2.) make the Angle ACD equal to 131d 34m. by drawing the Oblique Circle CA; and at D make the Angle ADC equal to 27d, 30m. by drawing the Oblique Circle DA and it's done.

To meaſure the Things required.

$$\text{The}\left\{\begin{array}{l}\text{Sides AC, and AD}\\ \text{Angle CAD ——}\end{array}\right\}\text{is meaſured by }\textit{Prob.}\left\{\begin{array}{l}7.\\ 8.\end{array}\right.$$

Prob. 20. *Three Sides given: to make a Triangle.*

Example, *Plate* 4. *Fig.* 11.

$$\text{The Side}\left\{\begin{array}{l}\text{AD 65d. 20m}\\ \text{CD 38d. 26m}\\ \text{AC 34d. 08m}\end{array}\right\}\text{given:}$$

With them to make an Oblique Triangle is required.

1. On the Primitive Circle make AD equal to 65d. 20m. (the greater given Side,) by *Prob.* 6. *Caſe* 1.

2. Draw (by *Prob.* 9. *Caſe* 2.) a Parallel Circle at 34d. 08m. Diſtance from A; and likewiſe another at 38d. 26m. Diſtance from D, to cut each other in C.

3. Through A and C, and alſo D and C, draw Great Circles, and it's done.

To meaſure the Things required,

1. Find (by *Prob.* 1.) the Poles of the three Sides of the Triangle A C D; that is, E the Pole of AD, F the Pole of AC, and G the Pole of C D.

2. Through F and G (by *Prob.* 4.) draw a Great Circle which will form the Triangle EFG.

3. The Sides of the Triangle EFG are equal to the Angles of the Triangle ACD; and the Angles of the firſt are equal to the Sides of the latter, only the greater Angle in the one, is equal to the Supplement (of the greater Side in the other) to 180d.

That is; the Side EF is equal to the Angle CAD, the Side EG is equal to the Angle ADC, and the Side FG is equal to the Supplement to 180d. of the Angle ACD.

4. The Sides EF, EG, and FG, are meaſured by *Prob.* 7.

Prob. 21. *Three Angles given; to make a Triangle.*

Example. *Plate* 4. *Figure* 12.

The Angle { CAD 131d. 34m.
ACD 30d. 47m.
ADC 27d. 30m. } given;

With them to make an Oblique Triangle, is required?

1. Suppoſe a Triangle EFG, whoſe Sides are equal to the Angles of the Triangle ADC; that is, the Side EF equal to 48d. 26m. the Supplement to 180d. of the Angle CAD equal to 131d. 34m. and the Side E G equal to the Angle ACD 30d. 47m. and the Side F G equal to the Angle ADC 27d. 30m.

2. Then make the Triangle E F G of the Sides EF; EG and FG; as before in the laſt Problem.

3. Find (by *Prob.* 1.) the Poles of the three Sides of the Triangle EFG; that is, A the Pole of EF, C the Pole of EG, and D the Pole of FG.

4. Through C and D (by *Prob.* 3) draw a Great Circle, which will form the Triangle ACD required to be made.

To meaſure the Things required.

The Sides AC, AD, and CD, are meaſured by *Prob.* 7.

Thus much I thought neceſſary as preparative to Spheric Trigonometry by Calculation; that the Learner might know how to make and meaſure a Spheric Triangle, or any of its Parts; a thing not taught by many, nor well underſtood by more, who pretend to be Teachers.

Sect. III. *Of the Affections or Natural Properties of* Spheric Triangles.

Theſe *Affections* are carefully to be minded, in order to the underſtanding what may be, and what may not be given, or required in a Spheric Triangle; and having already given you the ſeveral Definitions of a Sphere, and the Circles of it, with the Kinds of Triangles, which I will not here repeat. I paſs on to the *Affections of Spheric Triangles*, as follows.

1. Every Side of a Spheric Triangle is an Arch of a Great Circle, and leſs than a Semi-Circle.

2. Every Great Circle divides the Sphere or Globe, into two equal Parts or Hemiſpheres.

3. Any two Great Circles cutting each other; the Angles, which are oppoſite and contrary, are equal.

4. The Sum of any two Sides (of a Triangle) is greater than the third Side.

5. *The ſum of the three* {Sides / Angles} is leſs than {360d. / 540d.} but more than 180d.

6. Any two Sides added together, their Sum is leſs than the Difference between the third Side and 180d. But,

Any two Angles added together, their Sum is more than the Difference between the third Angle and 180d.

7. In a Rectangular Triangle, the Legs and their oppoſite Angles are of the ſame Affection; that is, if a Leg be more or leſs than a Quadrant, its oppoſite Angle is likewiſe more or leſs than a Right angle.

8. In a Rectangular Triangle, if one Leg be a Quadrant, the Hypotenuſe ſhall be a Quadrant; but if both Legs be of the ſame Affection, the Hypotenuſe is leſs than a Quadrant; if of different, it's more, and the contrary; that is, if each of the Legs be leſs or more than 90d. the Hypotenuſe is leſs than 90d. But if one Leg be more than 90d. and the other leſs, the Hypotenuſe is more than 90d.

9. If the Hypotenuſe be {leſs / more} than 90d. one Leg, and its oppoſite Angle will be {leſs than 90d. the other may, or not. / more, and the other leſs than 90d.}

10. If both Angles at the Hypotenuſe are acute or obtuſe, the Hypotenuſe is leſs than a Quadrant, but if one be acute, and the other obtuſe, the Hypotenuſe is more than a Quadrant.

11. In every Triangle, Greateſt Sides are oppoſite to Greateſt Angles, and Equal Sides to Equal Angles.

12. In every *Oblique Triangle two* $\begin{Bmatrix}\text{Acute}\\ \text{Obtuſe}\end{Bmatrix}$ *Angles* being equal their oppoſite ſides are equal, each $\begin{Bmatrix}\text{leſs}\\ \text{more}\end{Bmatrix}$ than a Quadrant.

13. *If two* $\begin{Bmatrix}\text{Acute}\\ \text{Obtuſe}\end{Bmatrix}$ *Angles* are unequal, the Side oppoſite to the $\begin{Bmatrix}\text{leſſer}\\ \text{greater}\end{Bmatrix}$ Angle, ſhall be $\begin{Bmatrix}\text{leſs}\\ \text{more}\end{Bmatrix}$ than a Quadrant.

14. All the *Angles* acute, each ſide is leſs than a Quadrant.

Theſe things being premiſed, their Solution followeth; and firſt of *Rectangular*, in which are 16 Caſes; and then Obliquangular, in which are 12 Caſes.

Sect. IV. *The Solution of the 16 Caſes of* Rectangular Spheric Triangles, *by the Lord* Napier's *Catholick Propoſition.*

1. IN a Rectangular Triangle, there are (beſides the Right-Angle) five Things, which the Lord *Napier* calleth the five Circular Parts of a Spheric Triangle, amongſt which, the Right Angle being not reckon'd, the two Legs are ſuppoſed to join together.

2. Any one of theſe five Circular Parts, may, by Suppoſition be made a middle Part, and then the two Circular Parts which art next to that middle Part, are the Extreams Conjunct. And the other (two Circular Parts) remote from that (aſſumed Middle Part) are the Extreams Disjunct.

3. In every Caſe, two of the aforeſaid five Circular Parts, is (always) given to find a third; theſe Three things (two given, and one required) of them, one is Middle Part, and the other two are Extreams, either Conjunct or Disjunct.

The Parrs of a Rectangular Triangle being thus diſtinguiſhed, obſerve the univerſal Propoſition following, invented by the aforeſaid Lord, the Inventor of *Logarithms.*

The Catholick Propoſition.

The Sine of a middle Part and Radius, are reciprocally proportional with the Tangents of the Extreams Conjunct; and with the Sine Complement of the Extreams Disjunct. That is

1. For Extreams Conjunct, thus ;

As Radius, is to the Tangent of one Extream ; ſo is the Tangent of the other, to the Sine of the middle Part. And,

2. For Extreams Disjunct, thus ;

As Radius, is to the Sine Complement of one Extream ; ſo is the Sine Complement of the other, to the Sine of the middle Part, Therefore,

Note ; When the middle Part is to be found, the Radius is the 1ſt Term in the Propoſition, as above ; But if either of the Extreams be required, the other Extream muſt be the firſt Term. That is,

3. For Extreams Conjunct, thus ;

As the Tangent of the given Extream, is to Radius ; ſo is the Sine of the middle Part, To the Tangent of the required Extream. And,

4. For Extreams Disjunct, thus ;

As the Sine Complement of the given Extream, is to Radius ; ſo is the Sine of the Middle Part, to the Sine Complement of the required Extream. But,

Note 1. That if the middle Part, or either of the Extreams Conjunct be the Hypotenuſe, or either of the Oblique Angles ; inſtead of Sine and of Tangent, you muſt uſe the Sine Complement, and Tangent Complement.

A TABLE of all the Varieties of Extreams Conjunct and Disjunct.

Number	*Middle Part*	*Ext. Conjunct*	*Ext. Disjunct*
1	*Sine* A B	*Tang.* BC *Tang. c.* BAC	*Sine* ACB *Sine* AC
2	*Sine c.* BAC	*Tang. c.* AC *Tang.* AB	*Sine c.* BC *Sine* ACB
3	*Sine c.* AC	*Tang. c.* BAC *Tang. c.* ACB	*Sine* BC *Sine* AB
4	*Sine c.* ACB	*Tang. c.* C *Tang.* BC	*Sine* BAC *Sine c.* AB
5	*Sine* BC	*Tang.* AB *Tang. c.* ACB	*Sine* BAC *Sine* AC

2. If either of the Extreams Disjunct be the Hypotenuſe, or either of the Oblique Angles, inſtead of Sine Complement you muſt uſe the Sine.

And for the eaſier underſtanding theſe Directions, obſerve the Table foregoing; wherein are placed the five Circular Parts of a Triangle, under their reſpective Titles, whether they be taken for the middle Part, or for Extreams, either Conjunct or Disjunct: And unto thoſe Parts are prefixed, Sine, Sine-Complement; Tangent and Tangent Complement, as they ought to be, and are uſed in the Caſes following.

Prob. 1. Caſe 1, 2, *and* 3. *The Hypotenuſe, and one Leg given;*

To find { 1. 2. 3. } The { Angle adjacent / Angle oppoſite } to the given Leg?
{ Other Leg

Example. *Plate* 4. *Fig.* 1.

In the Triangle *ABC*, Right angled at *B*; there is given
the { Hypot. *AC* 54d. 25m. / Leg *BC* 23d. 30m. } *ACB*, *BAC* and *AB* —— } required?

This Triangle is made by *Prob.* 10. of *Spheric Trigonometry Geometrical.*

1. For the contained Angle *ACB* or Angle adjacent to the given Leg, the Proportion is;

As Radius is to the Tangent of the given Leg; ſo is the Tangent Complement of the Hypotenuſe, to the Sine Complement of the contained Angle required. Or thus,

Radius ·· T. Leg *BC* :: T.c.Hypot. *AC* ·· S.c. Angle *ACB*
T.45d... T.23d.30m.:: T. 35d. 35m, ·· S. 18d. 16m.
Which ſubtract from 90d. reſts 71d. 54m, for the Angle *ACB* required.

Therefore the Extent (on the *Gunter's Scale*) from Tangent of 45d. to Tangent of 23d. 30m. reacheth from Tangent 35d. 35m. to the Tangent 17d. 15m. againſt which on the Line of Sines, is 18d. 6m. the 4th Term in the Proportion above.

Note, the *Hyp.* and given *Leg* { each / one } more { or —— / the other } leſs
than a Quadrant, or 90d. the required Angle is { Acute / Obtuſe

2. For the Angle *BAC* oppoſite to the given Leg, the Proportion is thus;

As the Sine of the Hypotenuſe, is to Radius; ſo is the Sine of the given Leg, to the Sine of its oppoſite Angle. Or thus;

S. Hipot. *AC* .. Radius : : S. Leg *BC* .. S. *Angle BAC*
S. 54d. 25m. .. S. 90d. : : S. 23d. 30m. .. Sine 29d. 30m.

Therefore the Extent (on the *Gunter*) from Sine 54d. 25m. to Sine of 90d. reacheth from Sine of 23d. 30m. to Sine of 29d. 30m. the 4th Term in the Proportion aboveſaid.

Note; the given Leg $\left\{\begin{array}{l}\text{leſs}\\ \text{more}\end{array}\right\}$ than a Quadrant, the requir'd Angle is $\left\{\begin{array}{l}\text{Acute}\\ \text{Obtuſe}\end{array}\right.$

3. For the other Leg AB, the Proportion is thus;

As the *Sine-Complement* of the given Leg, is to Radius; ſo is the *Sine-Complement* of the Hypotenuſe, to the *Sine-Complement* of the required Leg; or thus;

S.c. Leg *BC* .. *Radius* : : S c. Hip. *AC* .. S.c. Leg *AB* required
S. 66d. 30m. .. S. 90d. : : S. 35d. 35m. .. S. 39d. 35m. Which ſubtract from 90d. reſteth 50d. 25m. for the Leg *AB* requir'd.

Therefore the Extent (on the *Gunter*'s *Scale*) from *Sine* of 66d. 30m. to *Sine* of 90d. will reach from *Sine* of 35d. 35m. to *Sine* of 39d. 35m. the fourth Term in the Proportion aforeſaid.

Note; The Hipotenuſe and given Leg of $\left\{\begin{array}{l}\text{one} ——\\ \text{different}\end{array}\right\}$ kind the required Leg is $\left\{\begin{array}{l}\text{leſs}\\ \text{more}\end{array}\right\}$ than a Quadrant

Prob. 2. Caſe 4, 5, *and* 6.

The Hypotenuſe, and one Angle given;

To find $\left\{\begin{array}{l}1.\\ 2.\\ 3.\end{array}\right.\left.\begin{array}{l}\text{Leg oppoſite}\\ \text{Leg adjacent}\\ \text{other Angle}\end{array}\right.$ $\left.\begin{array}{l}\\ \\ \end{array}\right\}$ to the given Angle?

Example. *Plate* 4. *Fig.* 2.

In the Triangle *ABC* Right-angled at *B*; there is given $\left\{\begin{array}{l}\text{Hipot. } AC \text{ 54d. 25m.}\\ \text{Angle } BAC \text{ 29d. 30m.}\end{array}\right\}$ Leg *BC* and *AB*, and Angle *ACB* required?

This Triangle is made by *Prob.* 11. of *Spheric Trigonometry, Geometrical.*

1. For the Leg *BC* oppoſite to the given Angle, the Proportion is thus;

As Radius is to the *Sine* of the Hypotenuſe; ſo is the *Sine* of the given Angle, to the *Sine* of its oppoſite Leg required. Or thus;

Radius .. S. Hipot. *AC* :: S. Angle *BAC* .. S. Leg BC
S. 90d. .. S. 54d. 25m. :: S, 29d. 30m. .. S. 23d. 32m.

Note; The given Angle $\left\{\begin{array}{l}\text{Acute}\\ \text{Obtuſe}\end{array}\right\}$ the Leg found is $\left\{\begin{array}{l}\text{leſs}\\ \text{more}\end{array}\right\}$ than a Quadrant

2. For the Leg AB, adjacent to the given Angle the Proportion is this ;

As the *Tangent Complement* of the Hypotenuſe, is to Radius; ſo is the *Sine Complement* of the given Angle, to the Tangent of its adjacent Leg required. Or,

As Radius, is to the Sine Complement of the given Angle; ſo is the Tangent of the Hypotenuſe, to the Tangent of the Leg required ; That is,

Radius .. S c. BAC :: T. Hipot. AC .. T. Leg AB required.
S. 90d. .. S. 60d 30m :: T. 54d. 25m. .. T. 50d. 30m.

Note; When each given Thing is leſs, or more than 90d, the required Leg is leſs than a Quadrant, but if one is leſs, and the other more, the required Leg is more than a Quadrant.

3. For the other Angle ACB, the Proportion is this ;

As the *Tangent Complement* of the given Angle is to Radius; ſo is the *Sine Complement* of the Hypotenuſe, to the *Tangent Complement* of the other Angle required. Or thus ;

As Radius, is to the *Sine Complement* of the Hypotenuſe; ſo is the Tangent of the given Angle, to the *Tangent Complement* of the Angle required. That is ;

Radius .. Sc. Hipot. AC :: T. Angle BAC .. Tc. Angle ACB
S. 90d. .. S. 35d. 35m. :: T. 29d. 30m. .. T. 18d. 10m.
which ſubtract from 90d, reſts 71d. 50m for the Angle ACB

Note; When each given thing is leſs, or more than 90d. the required Angle is Acute : but when one is more, and the other leſs, it's Obtuſe.

Prob. 3. Caſe 7, 8 and 9. *A Leg and its adjacent Angle, given*

To find $\left\{\begin{array}{l}1\\ 2.\\ 3.\end{array}\right\}$ The $\left\{\begin{array}{l}\text{Leg}\\ \text{Angle}\\ \text{Hypotenuſe}\end{array}\right.$ oppoſite to the given $\left\{\begin{array}{l}\text{Angle}\\ \text{Leg}\end{array}\right.$

Example. *Plate* 4. *Fig.* 3.

In the Triangle ABC, Right Angled at B, there is
given $\left\{\begin{array}{l}\text{Leg —— AB 50d. 30m}\\ \text{Angle BAC 29d. 30m}\end{array}\right\}$ Leg BC, Angle ACB, and Hypotenuſe AC required

This Triangle is made by *Prob.* 12. of *Spheric Trigonometry Geometrical.*

1. For the Leg BC oppoſite to the given Angle, the Proportion is;

As the Tangent Complement of the given Angle is to Radius; ſo is the Sine of it's adjacent Leg, to the Tangent of its oppoſite Leg required. Or thus;

As Radius, is to the Sine of the given Leg; ſo is the Tangent of its adjacent Angle to the *Tang.* of its oppoſite Leg. That is;

Radius ·· S. Leg A B : : T. Angle BAC ·· T. Leg BC req.
S. 90d. ·· S. 50d. 30m. : : T. 29d. 30m. ·· T. 23d. 35m:

Note; The given Angle Acute, the required Leg is leſs than a Quadrant, but when Obtuſe then more than a Quadrant.

2. For the Angle *ACB*, oppoſite to the given Leg, the Proportion is;

As Radius, is to the Sine Complement of the given Leg; ſo is the Sine of its adjacent Angle to the Sine Complement of its oppoſite Angle required. That is,

Radius ·· S.c. Leg *AB* : : S. Angle *BAC* ·· S.c. Angle *ACB* req.
S. 90d. .. S. 39d. 30m. ; : S. 29d. 30m. ·· S. 18d. 12m.
whoſe Complement 71d. 48m. is the Angle *A C B.*

Note, The given Leg leſs or more than 90d. the Angle required is Acute, or Obtuſe accordingly.

2. For the Hypotenuſe, the Proportion is:

As the Tangent of the given Leg, is to Radius, ſo is the Sine Complement of its adjacent Angle, to the Tangent Complement of the required Hypotenuſe. Or thus;

As Radius is to the Sine Complement of the given Angle; ſo is the Tangent Complement of its adjacent Leg, to the Tangent Complement of the Hypotenuſe. That is;

Radius ·· Sc. Angle BAC : : Tc. Leg AB ·· Tc. Hypoten. AC
S. 90d. ·· S. 60d. 30m. : : T. 39d: 30m. ·· T. 35d. 38m.
whoſe Complement 54d. 22m. is the Hypotenuſe AC.

Note; When each thing is leſs, or more than 90d. the Hypotenuſe is leſs than a Quadrant, but if one is leſs, and the other more, then the Hypotenuſe is more than a Quadrant.

Prob. 4. Caſe 10, 11 and 12. *A Leg and its oppoſite Angle given;*

To find { 1. 2. 3. } the { Leg / Angle / Hypotenuſe } adjacent to the given { Angle? / Leg? }

Example· *Plate* 4; *Fig* 4.

In the Triangle BAC, Right-angled at B; there is,

given { Leg ——BC 23d. 30m } Leg AB, Angle ACB, and
{ Angle BAG 29d. 30m } Hypotenuſe AC required.

This Triangle is made by *Prob.* 13, *of Spheric Trigonometry Geometrical.*

1. For the Leg AB adjacent to the given Angle, the Proportion is this:

As Radius, is to the Tangent of the given Leg; ſo is the Tangent Complement of its opoſite Angle to the Sine of the other Leg required. That is;

Radius .. T.Leg BC : : T.c. Angle BAC .. S. Leg AB req.
T. 45d. .. T.23d.30m : : T. 60d 30m. .. S. 50d. 25m.

Note; If the unknown Angle be Acute or Obtuſe, the required Leg accordingly is leſs or more than a Quadrant.

Or, The Hypotenuſe and given Leg, each leſs or more than 90d. the required Leg is leſs than a Quadrant, but if one is more and the other leſs, it's more than 90d.

2. For the Angle ACB adjacent to the given Leg, the Proportion is this;

As the Sine Complement of the given Leg is to Radius; ſo is the Sine Complement of its oppoſite Angle, to the Sine of it's adjacent Angle, That is,

S.c Leg BC .. Radius : : S.c.AngleBAC .. S, Angle ACB
S. 66d.30m. .. S. 90d, : : S. 60d. 30m. .. S. 71d. 48m.

Note; If the Hypotenuſe and given Angle be each leſs, or more than 90d. the angle required is Acute; but when one is more, and the other leſs, it's Obtuſe.

Or, the Leg adjacent to the given Angle being leſs, or more than 90d. accordingly the Angle required is Acute or Obtuſe.

3. For the Hypotenuſe AC, the Proportion is this;

As the Sine of the given Angle, is to Radius; ſo is the Sine of its oppoſite Leg, to the Sine of the Hypotenuſe required. That is:

S. Angle BAC .. Radius : : S. Leg BC .. S.Hypoten.AC req.
S. 29d. 30m, .. S. 90d. : : S.23d.30m. .. S. 54d. 20m.

Note; If both Legs, or both Angles be of one Kind, the Hypotenuſe is leſs than a Quadrant, but if they be of different Kinds, the Hypotenuſe is more than a Quadrant.

Prob. 5. Caſe 13, and 14, *Both the Legs given; to find* 1, *Either of the Angles?* 2, *The Hypotenuſe?*

Example. *Plate* 4. *Fig.* 5.

In the Triangle *AB C*, Right angled at *B* ; there is,
given Leg { *AB* 50d. 30m. } Angle *BAC*, or *ACB*, and
{ *BC* 23d. 30m. } Hypotenuſe *AC* required.

This Triangle is made by *Prob.* 14. of *Spheric Trigonometry Geometrical.*

1. For either of the Angles, the Proportion is ;

As the Tangent of one Leg is to Radius; ſo is the Sine of the other Leg, to the Tangent Complement of the Angle oppoſite to the firſt Leg. Or thus,

As Radius, is to the Sine of one Leg ; ſo is the Tangent Complement of the other Leg, to the Tangent Complement of the Angle oppoſite to the laſt Leg. That is

Radius ·· S. Leg *AB* : : T.c. Leg *BC* ·· T.c. Angle *BAC*

S.90d... T.50d.30m : : T.66d.30m. ·· T. 60d. 35m. whoſe Complement is 29d. 25m. is the Angle *BAC*, alſo it is,

Radius ·· S. Leg *BC* : : T.c.Leg *AB* ·· T c. Angle *ACB*

S. 90d... S.23d.30m. ;: T.39d.30m. ·· T. 18d. 15m. whoſe Complement 71d. 45m. is the Angle *ACB*.

Note, If the Leg oppoſite to the required Angle be leſs than a Quadrant, the Angle ſought is Acute; but when greatter, then it's Obtuſe.

2. For the Hypotenuſe, the Proportion is thus :

As Radius, is to the Sine Complement of one Leg, ſo is the Sine Complement of the other Leg, to the Sine Complement of the Hypotenuſe. That is ;

Radius ·· S.c. Leg *AB* : :S.c. Leg *BC* ·· Sc. Hypotenuſe *AC*

S. 90d. ·· S.39d.30m. :: S. 66d: 30m. ·· S. 35d. 40m. whoſe Complement 54d. 20m. is the Hypotenuſe *AC*.

Note ; If both Legs be of one kind, the Hypotenuſe is leſs than a Quadrant, but when of different kinds (that is one Leg more the other leſs than a Quadrant ;) then the Hypotenuſe is more than a Quadrant.

Prob. 6. Caſe 15, and 16, *Both the Oblique Angles given ; to find* 1. *Either of the Legs ?* 2. *The Hypotenuſe ?*

Example. *Plate* 4. *Figure* 6.

In the Triangle *ABC*, Right angled at B; there is given
Angle { BAC 29d. 30m. } Leg AB or BC, and
{ ACB 71d. 56m. } Hypotenuſe AC required.

This Triangle is made by *Prob.* 15. *of Spheric Trigonometry Geometrical.*

1. For either of the Legs, the Proportion is thus ;

As the Sine of one Angle is to Radius ; ſo is the Sine Complement of the other Angle, to the Sine Complement of its oppoſite Leg. That is,

S Angle *BAC* ·· Radius : : S c. Angle *ACB* ·· S c. Leg *AB*
S. 29d. 30m. ·· S. 90d. : : S. 18d. 04m. ·· S. 40d 45m.
whoſe Complement 49d, 15m. is the Leg AB ; alſo it is,
S Angle *ACB* ·· Radius : : S c. Angle *BAC* ·· S c. Leg *BC*
S. 71d. 56m. ·· S. 90d. : : S. 60d 30m. ·· S 66d 30m.
whoſe Complement 23d. 30m. is the Leg *BC*.

Note ; If the Angle oppoſite to the required Leg be acute, the Leg ſought is leſs than a *Quadrant* ; but if obtuſe then greater than a Quadrant.

2. For the Hypotenuſe, the Proportion is thus ;

As Radius, is to the Tangent Complement of one *Angle* ; ſo is the Tangent Complement of the other Angle, to the Sine Complement of the Hypotenuſe. That is,

Radius ·· T c. Angle BAC : : Tc. Angle ACB ·· Sc. Hipot. *AC*
T. 45d. ·· T 60d 30m. : : T 18d 04m. ·· S 35d 35m.
whoſe Complement 54d 25m. is the Hypotenuſe AC

Note ; The Angles of one kind, the Hypotenuſe is leſs than a Quadrant ; but when of different kinds, its more than a Quadrant.

Sect. V. *Four Axioms, by which the 12 Caſes of Oblique-angled Spheric Triangles are ſolved.*

Axiom 1. IN all Spheric Triangles, the Sine of their Sides are in direct Proportion to the Sines of their oppoſite Angles. That is,

1. As the Sine of a Side, is to the Sine of its oppoſite Angle ; ſo is the Sine of another Side, to the Sine of its oppoſite Angle.

2. As the Sine of an Angle, is to the Sine of its oppoſite Side ; ſo is the Sine of another Angle, to the Sine of its oppoſite Side.

Axiom 2. *Firſt*, As the Sine of half the Sum of the two Sides (containing an Angle) is to the Sine of half their Difference.

So is the Tangent Complement of half the contained Angle, to the Tangent of half the Difference of the other two Angles

Again,

Secondly, As the Sine Complement of half the Sum of two Sides (containing an Angle) is to the Sine Complement of half their Difference ;

So is the Tangent Complement of half the contain'd Angle, to the Tangent of half the Sum of the other two Angles.

Axiom 3. *Firſt*, As the Sine of half the Sum of two Angles, is to the Sine of half their Difference, So is the Tangent of half their interjacent Side to the Tangent of half the Difference of the other two Sides. Again,

Secondly, As the Sine Complement of half the Sum of two Angles, is to the Sine Complement of half their Difference;

So is the Tangent of half their interjacent Side, to the Tangent of half the Sum, of the other two Sides.

Axiom 4. As the Rectangle of the Sines of the two containing Sides, is to the Square of Radius:

So is the Rectangle of the Sines of half the Sum of the three Sides, and of the Difference of the Side oppoſite therefrom, to the Square of the Sine Complement of half the contained Angle ſought.

The Explanation and Uſe of theſe 4 *Axioms*, you will find in the Solution of the following Caſes of *Obliqae Triangles*.

Prob 7. Caſe 1, 2, *and* 3.

Two ſides and an Angle oppoſite given; to find

1. The Angle oppoſite to the other Side,
2. The Angle contained between them,
3, The third Side

} if the required oppoſite Angle be foreknown to be Acute or Obtuſe.

Example. *Plate* 4. *Fig* 7.

In the Oblique Triangle ACD, *there is gi-*

ven	Side AC	34d.07m	Angle ACD	*being Obtuſe*	req.
	Side AD	65d.20m	Angle CAD	———	
	Angle ADC	27d.30m	Side CD	———	

This Triangle is made by *Prob.* 16. *of Spheric Trigonometry Geometrical.*

1. For the oppoſite Angle ACD, the Proportion by *Axiom* 1. is thus:

As the Sine of the Side AC, is to the Sine of the Angle ACD; ſo is the Sine of the ſide AD, to the Sine of the Angle ACD. That is;

S. Side AC .. S. Angle ADC : : S. Side AD .. S. Ang. ACD req.
S. 34d.07m .. S. 27d. 30m. : : S. 65d.20m .. S. 48d. 25m

Which ſubtract from 180d reſteth 131d. 35m. for the Angle ACD being Obtuſe.

2. For the contained Angle CAD (having before found the oppoſite Angle) the Proportion by *Axiom* 2. *Part* 1. inverted is thus;

As the Sine of half the Difference of the Sides AD and AC, is to the Sine of half their Sum; ſo is the Tangent of half the Difference of the Angles ACD and ADC, to the Tangent Complement of half the Angle CAD. And

3. For the 3*d* ſide CD (having found the oppoſite Angle) the *Prportion* by *Axiom* 3. *Part* 1. inverted is thus;

As the Sine of half the Difference of the Angles ACD, and ADC, is to the Sine of half their Sum.

So is the Tangent of half the Difference of the Sides AD and AC, to the Tangent of half the Side CD. That is;

d m — d m.
Side AD 65.20 — Ang·ACD 131.35
Side AC 34.07 — d m — Ang. ADC 27.30 — d m
Sum is 99.27 } ½ { Sum 49.43 — Sum is 159.05 } ½ { Sum 79 32
Differ. 31.13 } ½ { Diff. 15.36 — Differ is 104 05 } ½ { diff. 52 02

S. ½ *Diff. Sides* ·· S. ½ *their Sum* : : T. ½ *Diff. Angles* ·· T.c. ½ *CAD*
S. 15d. 36m. ·· S. 49d. 43m. : : T. 52d. 02m. ·· T.c. 74d. 40m.
Which ſubtract from ———————— 90d. 00m.
Remainder is ½ the Angle *CAD* ———————— 15d. 20m
Which being doubled ———————— 15d. 20m
Produceth the required Angle *CAD* ———————— 30d 40m

S. ½ *Diff. Angles* ·· S. ½ *their Sum* : : T. ½ *Diff. Sides* ·· T. ½ C D.
S. 52d. 02m. ·· S. 79d. 32m. : : T. 15d. 36m. ·· T 19d. 12m
Which being doubled ———————— 19d. 12m
Produceth the required Side CD ———————— 38d. 24m

Prob. 8. Caſe 4, 5, *and* 6.

Two Angles, and one Side oppoſite given; to find

1. The Side oppoſite to the other *Angle* }
2. The interjacent, or Side between them } if the required
3. The third Angle. ———————— }

oppoſite ſide be foreknown to be more, or leſs than a Quadrant

Example. *Plate* 4. *Figure* 8.

In the Oblique Triangle *ACD*; there is given

Angle CAD 30d. 48m } *Side* *AC* leſs than 90d. }
Angle ADC 27d. 20m } *Side* *AD* ———— } required.
Side *CD* 38d. 38m } *Angle* *ACD* ———— }

This Triangle is made by *Prob.* 17. *of Spheric Trigonometry Geometrical.*

1. For the oppoſite Side *AC*, the Proportion by *Ax.* 1. is thus;

As the Sine of the Ang. *CAD*, is to the Sine of the Side *CD*; ſo is the Sine of the Ang. *ADC* to the Sine of the Side *AC* That is;

S. Angle *CAD* ·· S. Side *CD* : : S Angle *ADC* ·· S. ſide *AC* req.
S. 30d. 48m. ·· S. 38d. 28m : : S 27d. 30m. ·· S. 34d. 06m.

2. For the interjacent Side AD, (having firſt found the oppoſite ſide) the Proportion, by *Ax.* 3. *Part* 1. inverted is thus;

As the Sine of half the Difference of the Angles C A D, and ADC, is to the Sine of half their Sum.

So is the Tangent of half the Difference of the Sides CD and AC, to the Tangent of half the Side AD. And,

3. For the third Angle ACD, (having first found the oppoſite ſide) the *Proportion, by Axiom 2. Part 1.* inverted is thus;

As the Sine of half the Difference of the Sides CD and AC, is to the Sine of half their Sum.

So is the Tangent of half the Difference of the Angles CAD and ADC, to the Tangent Complement of half the Angle ACD. That is;

	d. m.		d. m.		d. m.		d. m.
Ang. CAD	30 48			Side CD	38.28		
Ang. ADC	27.30			Side AC	34.06		
Sum is	58 18	$\frac{1}{2}$ Sum	29.09	Sum is	72 34	$\frac{1}{2}$ Sum	36.17
Differen.	03.18	$\frac{1}{2}$ Diff.	01.39	Differ	04.22	$\frac{1}{2}$ Diff.	02.11

S. $\frac{1}{2}$ Diff. Angles .. S. $\frac{1}{2}$ their Sum : : T. $\frac{1}{2}$ Diff. Sides .. Tc. $\frac{1}{2}$ AD
S. 01d. 39m. .. S. 29d. 09m. : : T. 02d. 11m. .. T. 32d. 38m
Which being doubled ———————— 32d. 38m
Produceth the interjacent Side AD to be ——— 65d. 16m.
S. $\frac{1}{2}$ Diff. Sides .. S. $\frac{1}{2}$ their Sum : : T. $\frac{1}{2}$ Diff. Angles .. Tc. $\frac{1}{2}$ ACD
S. 02d 11m. .. S 36d. 17m. : : T. 01d. 39m. .. T. 24d 14m
Which ſubtract from ———————— 90d. 00m
Remainder is half the Angle ACD ———— 65d. 46m
Which being dounbled ———————— 65d. 46m
Produceth Angle ACD to be ———— 131d. 32m.

Note; In the ſix preceeding *Caſes*, the three given Terms, without the Quality of a fourth are not ſufficient, whereby one ſingle Anſwer may be found; and the Quality of the fourth is not always diſcoverable by the given Terms: Therefore they are called the Six Doubtful Caſes.

Problem 9. Caſe 7 *and* 8.

Two Sides, and one Angle between them given; to find

1. *Either of the other Angles;*
2. *The third ſide, or ſide oppoſite to the given Angle.*

Example. *Plate* 4. *Fig* 9.

In the Oblique Triangle ACD; there *is gi-*
ven { Side AC 34d. 06m / Side AD 65d. 20m / Angle CAD 30d. 46m } { Angle ACD or / Angle ADC and / Side CD is—— } required.

This Triangle is made by *Problem* 18, of *Spheric Trigonometry Geometrical*, in Pages 129 and 130.

For the Angle ACD, or ADC, the Proportion (by *Axiom* 2.) is thus;

	d. m.		d. m.		d. m.
Side AD	65.20	Angle CAD	30.46		
Side AC	34.06	The half is	15.23		74.37
Sum of Sides	99.26	The $\frac{1}{2}$ Sum	49.43	its Comp.	40.17
Differ. Sides	31.14	Diff.	15.37		74.23

As S. $\frac{1}{2}$ *Sum* AD&AC .. S. $\frac{1}{2}$ *their diff.* :: T.c. $\frac{1}{2}$ CAD .. T. $\frac{1}{2}$ *diff. An*

As S. 49d. 43m. .. S. 15d. 37m. :: T. 74d 32m .. T. 52d. 02m.

Then again,

As Sc. $\frac{1}{2}$ *Sum ſides* .. S.c. *their Diff.* :: T.c. $\frac{1}{2}$ CAD .. T. $\frac{1}{2}$ *Sum Angles*

As S. 40d. 17m. .. S. 74d. 23m. :: T. 74d. 37m .. T. 79d. 32m.

To it add the half Difference found above —— 52d. 02m.

The Sum is the greater Angle ACD —— 131d. 34m.

And being ſubtracted, is the leſſer Angle ADC 27d. 30m

Note, If the Sum of the two contained Sides exceeds a Semicircle, then ſubtract each ſide from 180 Degrees, and proceed with thoſe Remainders as with the Sides given; the Proportion produces the Complements of the Angle required to a Semicircle.

For the third Side CD, or Side oppoſite to the given Angle, as alſo in *Caſe* 10. following, the Proportion (after the work above is done) may be made by *Axiom* 1. Or it may be deduced from the Lord *Napiers Catholick* Propoſition (by a given Perpendicular, let fall from one end of the leſſer given Side, to the greater Side given, reducing the Oblique Triangle into two Rectangulars) Which finds the Side oppoſite to the given Angle at two Proportions, without finding the Angles; and it's thus.

1. As Radius, is to the Sine Complement of the contained Angle; So is the Tangent of the leſſer given Side to the Tangent of a Fourth Arch.

Then, if the contained Angle be Acute, ſubtract the Fourth Arch from the greater given Side, but when it is Obtuſe from the Supplement thereof to 180 Degrees, the Remainder is called the *Reſidual Arch*. Then,

2. As the Sine Complement of the Fourth Arch, is to the Sine Complement of the *Reſidual Arch*.

So is the Sine Complement of the leſſer given Side, to the Sine Complement of the Side required. That is:

As Radius .. S c. *Angle* CAD : : T. Side AC .. T. Fourth Arch

As S 90d .. S. 59d. 14m. : : S. 34d. 06m. .. T. 30d 12m Which being ſubtracted from the Side AD —— 65d. 20m.

The Remainder is the Reſidual Arch —— 35d. 08m. Then

As S. c 4th *Arc.* .. S. c. *Reſid. Arch* : : S c *Side* AC .. S. c. Side CD

As S. 59d. 48m .. S. 54d. 52m. : : S. 55d. 54m. .. S 51d. 35m.

Whoſe Complement 38d. 25m. is the Side CD required.

Note, When the contained Angle, and Reſidual Arch, are each leſs, or more than 90 Degrees, the Side ſought is leſs than a Quadrant. But when one is more and the other leſs, it's more than a Quadrant.

Problem 10. *Caſe 9 and 10.*

Two Angles and one Side between them given; to

find { 1. *Either of the other Sides?*
{ 2. *The Angle oppoſite to the given Side?*

Example. In the Oblique Triangle ACD; there is given,

The { Angle ACD 131d. 34m. { Side AC or, } required
{ Angle ADC 27d. 30m. { Side AD and }
{ Side CD 38d. 28m. { Angle CAD is }

This Triangle is made by *Problem* 19. of *Spheric Trigonometry Geometrical*, in *Page* 130. ſee *Plate* 4. *Fig.* 10.

For the Side AC, or AD, the *Proportion* (by *Axiom* 3.) is thus;

d. m. d. m.

Angle ACD 131.34 | The *Side* CD 38.28

Angle ADC 27.30 | The $\frac{1}{2}$ is —— 19.14 d. m.

Sum of Angles 159.54 } The $\frac{1}{2}$ { *Sum.* 79.32 } it's *Com.* { 10.28

Difference is 104 04 } { *Diff.* 52.02 } { 37.58

As S $\frac{1}{2}$ *Sum Ang.* .. S $\frac{1}{2}$ their Dif. : : T. $\frac{1}{2}$ Side CD .. T. $\frac{1}{2}$ Dif. Sides

As S. 79d. 32m .. S. 52d. 02m. : : T. 19d. 14m. .. T. 15d. 38m.

The again,

S. c. $\frac{1}{2}$ *Sum Ang.* .. S. c. $\frac{1}{2}$ *their Diff.* : : T. $\frac{1}{2}$ *Side* CD .. T. $\frac{1}{2}$ *Sum Sides*

As S. 10d. 28m .. S. 37d. 58m. : : T. 19d. 14m. .. T. 49d. 45m.

To it add the half Difference found above —— 15d. 38m.

The Sum is the greater Side AD —— —— 65d. 23m

And being ſubtracted, is the leſſer Side AC —— 34d. 07m.

Note; If the Sum of the two given Angles exceed 180deg. then ſubtract each given Angle from 180 Degrees, and proceed with thoſe Remainders as with the Angles given; the Operation will produce each required Side's Supplement to 180 Degrees.

For the Angle CAD, the Angle oppoſite to the given Side, the Proportion (after the Work above is done) may be by *Axiom* 1. Or from the *Catholick Propoſition* (by a Perpendicular let fall from the greater given Angle to its oppoſite ſide) thus;

1. As Radius, is to the Sine Complement of the interjacent Side; So is the Tangent of the leſſer given Angle, to the Tangent of a Fourth Arch.

Then, if the interjacent Side be more than a Quadrant, ſubtract the Fourth Arch from the greater given Angle, but when it's leſs, from the Supplement thereof to 180 Degrees, the Remainder is the Reſidual Arch. Then,

2. As the Sine Complement of the Fourth Arch, is to the Sine Complement of the Reſidual Arch.

So is the Sine Complement of the leſſer given Angle, to the Sine Complement of the Angle required. That is;

As Radius ·· S.c. SideCD : : T. Angle ADC ·· T. 4th Arch.
As S.90d. .. S. 51d. 32m. : : T. 27d. 30m. .. T. 22d. 10m.
which ſubtr. from (the Suppl. of the Ang. ACD) 48d. 26m.

The Remainder is the Reſidual Arch ——— 26d. 16m.
Then,
S.c.4th *Arch* ·· S.c.*Reſid Arch* : : S.c.*Ang.*ADC ·· S.c.*Ang.*CAD req.
S. 67d. 50m. .. S. 63d. 44m. : : S. 62d. 30m. .. S. 59d. 12m.
whoſe Complement 30d. 48m. is the Angle CAD required.

Note; When the interjacent Side and Reſidual Arch are each leſs, or each more than 90d. the Angle ſought is Acute; but when one is more, and the other leſs, it's Obtuſe.

Problem 11. Caſe 11. *Three Sides given to find either of the Angles?*

Example. *Plate* 4. *Fig.* 11,

In the Oblique Triangle ACD there is given,

$$\text{The Side}\left\{\begin{array}{l}\text{AD 65d. 20m.}\\ \text{CD 38d. 26m.}\\ \text{AC 34d. 08m.}\end{array}\right\}\ \text{Angle}\left\{\begin{array}{l}\text{ACD, or}\\ \text{ADC, or}\\ \text{CAD, required?}\end{array}\right.$$

This Triangle is made by *Problem* 20. of *Spheric Trigonometry Geometrical*, in *Pages* 130, 131.

The Reſolution of this and the following Caſe depends upon *Axiom* 4. and for the more ſpeedy Solution, obſerve theſe Directions, *viz.*

1. Add the Three Sides together, and from their half Sum ſubtract the Side oppoſite to the Angle required, noting the Remainder.

2. To the Complement Arithmetical of the Log-Sines of the containing Sides, add the Log-Sines of the half Sum and the Remainder: Half the Total of theſe 4 Logarithms, is the Log. Sine of half the required Angle's Supplement to 180 Degrees.

The Operation for the Angle ACD, is thus;

		d. m.		
Side	CD	38 26	The containing Sides	S. *co. ar.* 0.206487
	AC	34 08		S. *co. ar.* 0.250944
	AD	65 20	½ Sum Sides 68d. 57m. S. ——	9.970006
Sum is		137 54	Remainder is 3d. 37m. S. ——	8.799897
½ Sum is		68 57	Sum of the 4 Logarithms is	19.227334
Remain		3 37	24d. 15m. S ½ Sum	9.613667

Double it —— —— 24d. 15m.
The Sum is —— —— 48d. 30m.
Which ſubtract from —— 180d. 00m.
Remainder is the Angle ACD 131d. 30m.

In like manner you may find any other Angle by Logarithms,

But by Gunter's Scale *ſay*,

1. As Radius, is to the Sine of one of the containing Sides; So is the Sine of the other containing Side to a Fourth Sine. Then,

2. As that 4th Sine, is to the Sine of the half Sum of the Three Sides,

So is the Sine of of the Remainder, to a Fifth Sine; againſt which on the Line of verſed Sines is the Angle required.

That is,

As Radius .. S. Side CD : : S. Side AC .. a Fourth Sine.
As S. 90d. .. S. 38d. 26m. : : S. 34d. 08m. .. S. 20d. 26m.

Then again,

As Fourth Sine .. S. ½ Sum Sides : : S. Remainder .. a Fifth Sine
As S. 20d. 26m. .. S. 68d. 57m. : : S. 03d. 37m. .. S. 9d. 43m. againſt which on the Line of Verſed Sines, is 131d. 30m, the Angle ACD as before.

Problem 12. Caſe 12. *The Angles given; to find a Side.*

Example. *Plate* 4. *Figure* 12.

In the Oblique Triangle ACD; there is given the

Angle	ACD	30d. 47m.	: Side	CD, or
	ADC	27d. 30m.		AC, or
	CAD	131d. 34m.		AD, required.

This Triangle is made by *Problem* 21. *of Spheric Trigonometry Geometrical*, in Page 131.

This Caſe is likewiſe performed by the Directions in Caſe 11. the Angles being accounted Sides, and the Sides Angles; and then taking the Supplement of the greater (given) Angle to 180 Degrees.

For the Side AD, the Operation is thus;

	d. m.		
Sup. An. CAD	48 26	The adjacent Angles { S. *co. ar*	0.125992
Angle ADC	27 30	S. *co. ar.*	0.335595
Angle ACD	30 47	½ Sum Ang 53d 21m S ———	9.904335
Sum is	106 43	Remainder 22d 34m S. ———	9.584057
½ Sum is	53 21	Sum of the 4 Logarithms is	19 949979
Remainder	22 34	——— ——— 70.45 S. ½ Sum	9.974989

Double it ——— ——— 70 45

The Sum is ——— ——— 141 30 Which

Subtract from ——— 180.00

Remainder is the ſide AD 38.30

In like manner may any other Side be found by Logarithms; Or thus;

By Gunter's *Scale.*

1. As Radius, to the Sine of one of the adjacent Angles (to the Side required); ſo is the Sine of the other adjacent Angle to a Fourth Sine.

2. Then, as a Fourth Sine, is to the Sine of the half Sum of the Three Angles;

So is the Sine of the Remainder, to a Fifth Sine; againſt which, on the Line of Verſed Sines, is the Side required.

That is;

As Radius ·· S. Sup. CAD : : S. Angle ADC ·· a Fourth Sine

As S. 90d. ·· S. 48d. 26m. : : S. 27d. 30m. ·· S. 20d. 13m.

Then again,

As Fourth Sine ·· S. ½ Sum Angles : : S. Remainder ·· a Fifth Sine

As S. 20d. 13m. ·· S. 53d. 21m. : : S. 22d. 34m. ·· S. 20d. 13m.

Againſt which on the Line of Verſed Sines, is——38d. 30m. the Side AD as above.

Note; when the greater Side (CD, which ever is oppoſite to the greater Angle) is required, the Operation will produce the Supplement thereof to a Semicircle; wherefore if it be ſubtracted from 180d. it leaves the Side ſought: Or (by the

Logarithms) if you omit this part of the Operation (which ſubtract from 180 Degrees, &c.) you have the ſide required.

So much for the Doctrine of *Spheric Triangles* ; the Application follows.

CHAPTER VI.

Containing the Deſcription and Uſe of the GLOBES.

HAving finiſhed *Spheric Trigonometry*, it remains to ſhew its Uſes in *Geography*, *Great Circle-Sailing*, and *Aſtronomy* ; in order to the perfect underſtanding of theſe, it's requiſite firſt to be acquainted with the *Nature* and *Uſes* of the *Globes*, which I will endeavour to perform briefly and plainly.

Section I. *The Deſcription and Uſe of Globes in general.*

1. A *Globe*, as to it's Name and Figure is ſo generally known that it's needleſs here to produce a Mathematical Definition of it ; but as to the Kinds of Material Globes, and their Parts, it is neceſſary ſomething ſhould be ſaid.

2. The Kinds of Globes are two, Terreſtial and Cœleſtial, with together with their Appurtenances, are for the lively Repreſentation of the Natural Situation and Poſition of the Earth, and Heavens, and are uſeful for the demonſtrating (by Repreſentation and Reſolution of) any Problem belonging to the Sphere of *Heaven*, or *Earth*, either in *Geography*, *Navigation*, or *Aſtronomy*.

3. The Appurtenances appertaining to Material Globes are Six ; The Body or Globe it ſelf, Brazen Meridian, Quadrant of Altitude and its Screw, Hour-Circle and Index, Wooden Frame or Horizon, and Braſs Semi-Circle of Poſition ; all may be uſed with either Globe ; yet the laſt being of leaſt Uſe may be ſupplied by the Quadrant of Altitude.

4. The Body, or Globe it ſelf, is an Emblem of Heaven, or of Earth ; on which are drawn divers Lines, and Circles ; uſeful and proper for the underſtanding them.

5. The *Brazen Meridian*, is the Ring in which the Globe hangeth, and turneth upon its Axis; being two Wires, iſſuing forth its Body ; and is divided into 4 *Quadrants*, each 90 Degrees, and figured 10, 20, 30, &c. to 90.

Plate 4. Fig. I.

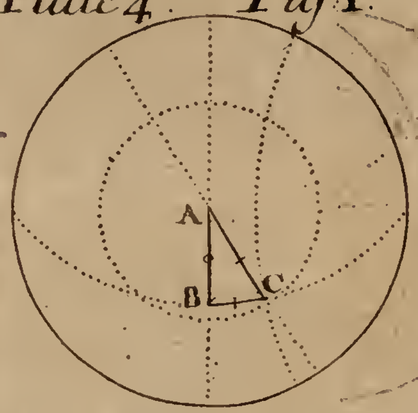


Fig. II.

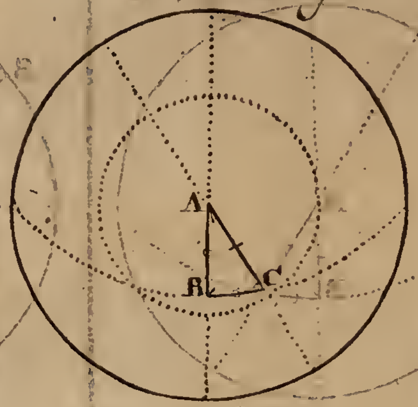


Fig: III.

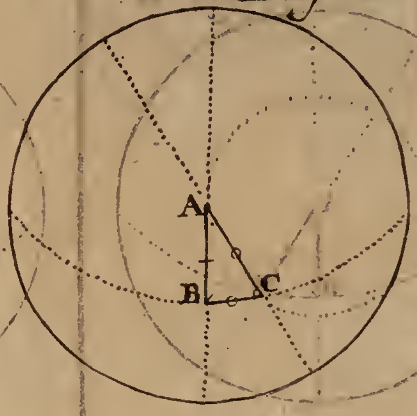
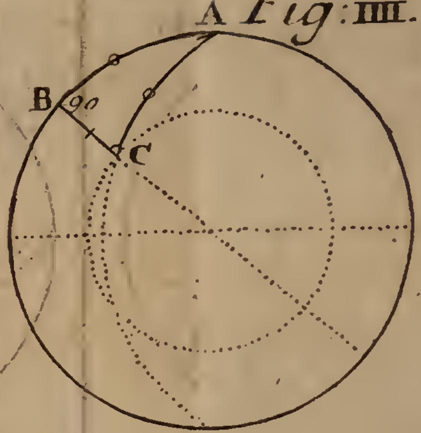


Fig: IIII.



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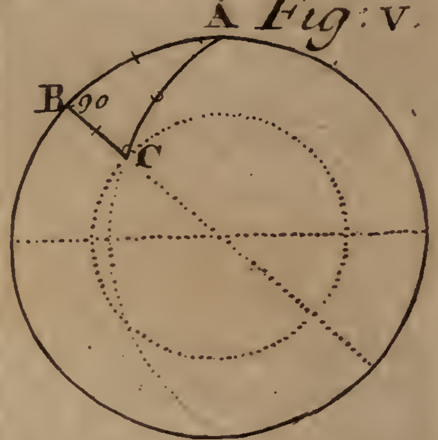


Plate 4. Fig: I.

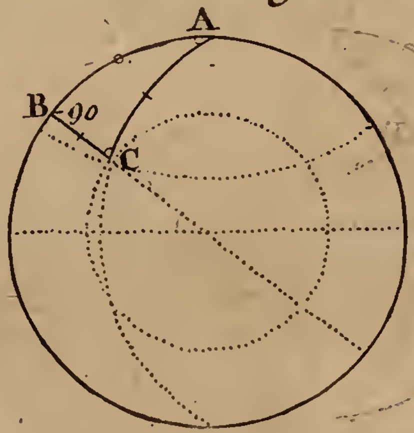


Fig: II.

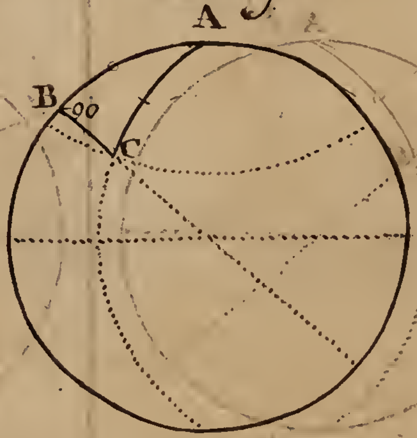


Fig III.

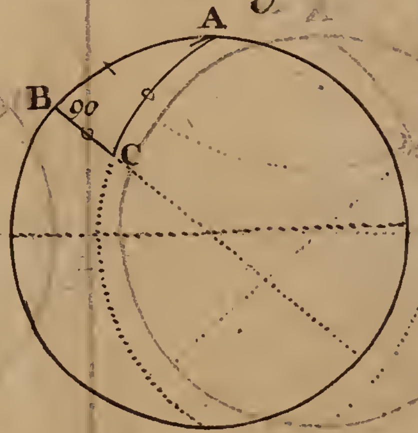


Fig VI.

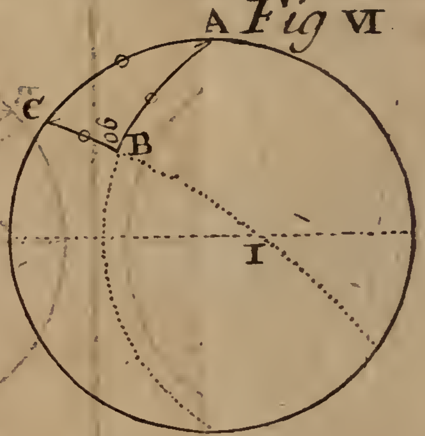


Fig: VII.

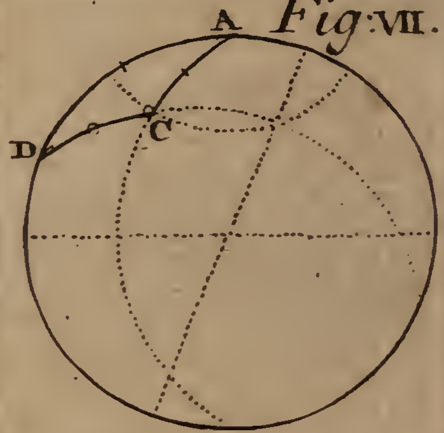


Fig VIII.

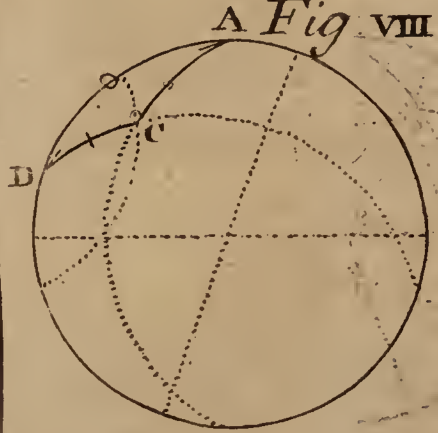


Fig IX.

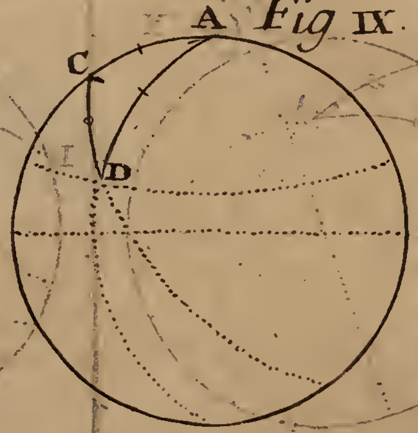


Fig: X.

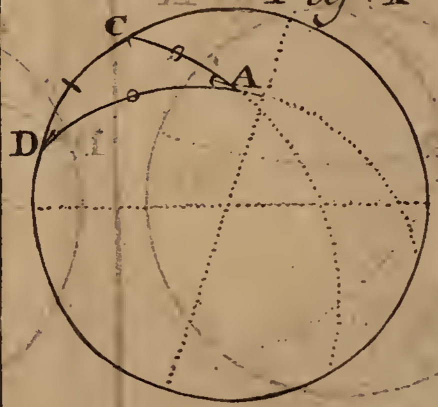


Fig: XI.

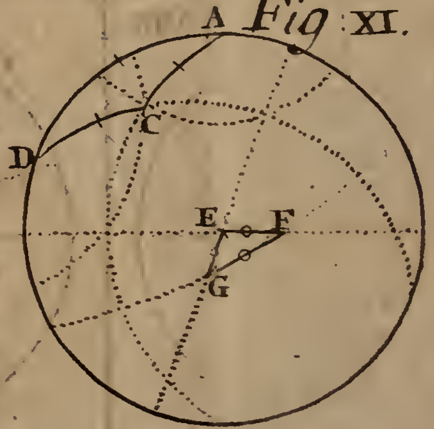
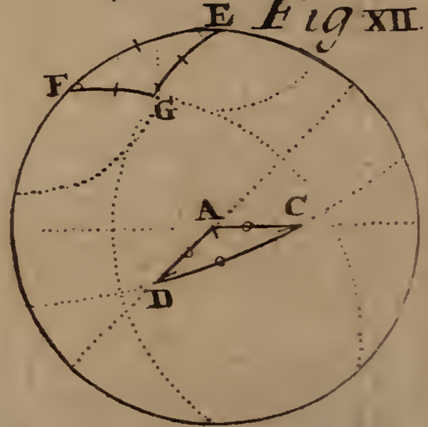


Fig XII.



6. The *Quadrant of Altitude*, is a narrow thin ſlip of *Braſs*, with a Notch, Nut, and Screw at one End; it's divided into 90d. which ſhew the Almicanthers, or Circles of Altitude, and the Edge repreſenteth an Azimuth Circle.

7. The *Hour Circle*, is a flat Ring of Braſs, ſo contrived that it may be took off, and fixed about either Pole of the Globe; it's divided into 24 Hours of a Natural Day; each Hour is divided in Halves and Quarters; to this belongs an Index, having a round Hole at one end, to put it on the *Axis of the Globe*.

8. The *Wooden Frame*, or *Horizon*, is round and flat; in which the Brazen Meridian doth move through two Notches, in the upper Part; another in the middle of the bottom of it: On the upper Part is a *Kalendar*, ſhewing the Day of the Month, Sun's Place in the Ecliptic, the Rumbs or Points of the Compaſs, &c.

9. The *Circle of Poſition*, is a Semi-Circle of Braſs, the upper ſide is divided into 180 Degrees, it ſerveth to meaſure Diſtances, either on the Terreſtial, or Cœleſtial Globe.

Section II. *The Deſcription and Uſe of the* Terreſtial Globe.

THE *Terreſtial Globe* hath on the Superficies of it's Body, the whole Form and Faſhion of the Earth and Sea, deſcribed; with the Circles of the Sphere, as Equator, Meridians, Tropics, &c.

In order to a clear Underſtanding the Uſe of this Globe, obſerve theſe following Geographic Definitions.

1. The *Earth*, together with the *Water*, compoſeth that round Body called the *Orb*, or Globe of the Earth, which is deſcribed by Lines Real and Imaginary.

2. The *Real-Lines* are ſuch as agree to the Terreſtial *Globe*, by Nature, and ſo divide it into Continents, Iſlands and Seas; the imaginary Parts, are ſuch as are applied to it by vertue of our underſtanding; and being not materially ſuch, are ſuppoſed to be on the Earth, theſe imaginary Lines are either Streight or Circular.

3. The *Axis*, is a Streight Line imagined to paſs through the *Center* of the *Earth*; the extream Points are the Poles, on which the World is ſuppoſed to move; one called the *Artic* or *North Pole*; the other the *Antartic* or *South Pole*; it's repreſented by the Wires on which the Globe turneth.

4. The *Circular Lines*, are either greater, as the *Meridian*, *Horizon*, *Æquator*; or leſſer, as *Tropics*, *Polar Circles*, *Parallels of Latitude*.

5. *Meridian*, is a Circle paſſing through the Poles of the Earth, the Zenith and Nadir, croſſeth the Æquator at Right Angles, and divideth the Earth into two equal Parts; one Eaſt the other Weſt. It's ſo called becauſe when the Sun cometh to the Meridian of any Place, it's then Noon, or Mid-day there; they are infinite in Number, for that all Places from Eaſt to Weſt have their ſeveral Meridians.

Of theſe one is called the *Firſt*, or *Chief Meridian*, from which the Longitude of Places is reckoned; it's of ſpecial note and uſe, but variouſly placed by *Geographers*: It's repreſented on the Globe by a double Line paſſing through the Poles, and is divided into twice 90 Degrees numbred from the Æquator, towards each Pole, ending there in 90 Degrees.

6. The *Horizon*, is that Circle which comprehendeth all that ſpace of the Earth which is viſible, and diſtinguiſheth it from that (lying under the Horizon) being inviſible; it's either Senſible or Rational.

The *Senſible Horizon*, is that apparent Circle which extends it ſelf in a ſtraight Line from the Place we ſtand upon, and round about us, dividing the Heavens into two unequal Parts; and being limited by the Sight, is ſometimes greater or leſſer, according to the Condition of the Place, &c.

The *Rational Horizon*, is a Circle dividing the Heavens into two equal Parts, paſſeth through the Center of the Earth whoſe Poles are the Zenith and Nadir. By this Circle our Days and Nights are meaſured, and the divers Riſings and Settings of the Sun, Moon, and Stars do appear: It's repreſented on the Globe by the upper Part of the *Wooden Frame.*

Note; The *Meridian* and *Horizon*; are moveable with the Mutation of Places.

7. The *Æquator*, is a Line under the Equinoctial in the Heavens, compaſſing the Earth in the Middle between its two Poles, dividing it into two equal Parts, called the Northern, and Southern Hemiſpheres; from it the Latitude of Places are reckoned, either North or South: This Circle is repreſented on the Globe by a Double, or Treble Line; divided into 360 Degrees, and numbred 10, 20, 30, &c. from the Left-hand towards the Right, till it end in 360 Degrees.

This Circle is called *Æquator*, becauſe when the Sun comes to it, which is twice a Year (*viz.* about the 10th of *March*, at his Entrance into *Aries*; and again into *Libra*, about the 12th of *September*) he makes equal Days, and Nights throughout the World. And upon it is writ in Capital Letters *Linea ſub Æquinoctiali.*

8. The *Leſſer Circles*, deſcribed on Globes, are called *Parallel Circles*, ſome of which have particular Names, as *Tropics*, and *Polar Circles.*

9. The *Tropics* are two, being Parallel to the Æquator, and diſtance from it 23d. 30m. That on the North ſide of it, is called the *Tropic of Cancer*, at which the Sun hath his greateſt North Declination: then making to us, (and all Places in North Latitude) the longeſt Day, and ſhorteſt Night; which is about the 11th of *June*: The other on the South-ſide, is called the *Tropic of Capricorn*, at which the Sun hath his greateſt South Declination, making then our ſhorteſt Day and longeſt Night; which is about the 12th of *December.* Theſe *Tropics* have their Names thus; *Tropicus ſub Cancri*, and *Tropicus ſub Capricorni.*

10. The *Polar Circles* are two being alſo Parallel to the Æquator, and compaſſing the Poles of the World, at 23d. 30m diſtance: That about the North Pole is called the *Artic-Circle*; and the other the *Antartic-Circle*, and are Writ thus; *Circulus ſub Artico Polo*, and *Circulus ſub Antartico Polo.*

Theſe *Tropics*, and *Polar Circles* divide the Globe of the Earth into Five Parts, called *Zones*: of which three were accounted by the Antients to be ſo intemperate as to be uninhabitable; calling them *Torrid*, *Friged*, and *Temperate*; that is one *Torrid* or burning *Zone*, two *Temperate*, and two *Frigid* or frozen *Zones*,

11. The *Torrid Zone*, is that which lieth between the two *Tropics of Cancer* and *Capricorn.*

12. The two *Temperate Zones* are contained between each Tropic, and a Polar Circle.

13. The two *Frigid Zones*, are contained within each *Polar Circle*; that is, one within the *Artic Circle*, and the other compaſſed by the *Antartic.*

Thus much of the *Imaginary Lines*, and Parts of the Earth: The Real Parts, are Earth and Water, in general divided into Four Parts or Quarters; called *Europe*, *Aſia*, *Afirica*, and *America*; each of theſe, and conſequently the whole Globe, is divided into Continents, Iſlands, and Seas.

14. *A Continent*, is a great Quantity of Land, not divided by the Sea, wherein are many Kingdoms, and Countries conjoined : as *Europe*, *Aſia*, and *Africa* in one Continent, and *America* is another.

15. An *Iſland*, is a part of the Earth that is environed or compaſſed round by *Water* ; as *Great-Britain*, and alſo *Ireland*, *&c* are Iſlands.

In *Continents*, and *Iſlands*, are theſe Parts obſervable, *viz. Peninſula*, *Iſthmus*, and *Promontory*.

16 *Peninſula*, is ſuch a Part of Land as is almoſt environed round with Water, and is joined with the Land by an *Iſthmus*, as the *Morea* in the *Levant*.

17. An *Iſthmus*, is a norrow Neck of Land between two *Seas*, which joineth the *Peninſula* to the *Continent* ; as *Corinth* in *Greece*.

18. A *Promontory* is a High Hill, Mountain, or Cape of Land that ſhooteth it ſelf into the Sea ; as *Cape de Verde*, and the Cape of *Good Hope* in *Africa*.

19. A *Place* in reſpect to the *Heavens*, is either Eaſt, Weſt, North or South.

Thoſe Places are ſaid to be Eaſt, which lie in the Eaſtern Hemiſphere (terminated by the Firſt Meridian) or where the Sun riſeth.

And thoſe are Weſt which lie Weſterly of the ſaid Meridian, or towards the Setting of the Sun.

Thoſe Places are properly North, which lie betwixt the Æquator and the Artic Pole.

And thoſe Places are South, which lie betwixt the Æquator and the Antartic Pole.

The Antients have divided the Inhabitants of the Earth into *Periœci*, *Antiœci*, and *Antipodes*.

20. The *Periœci*, are ſuch as live under the ſame Parallel, but in oppoſite points of it ; that is, they are in the ſame Latitude, but their Difference of Longitude is 180 Degrees.

21. The *Antiœci*, are ſuch as have the ſame Meridian, and equally diſtant from the Æquator, but the one North, and the other South : that is; Two Places in one Longitude, and each equal in Latitude ; one in North, and the other in South Lat.

22. The *Antipodes* are ſuch as Inhabit two Places of the Earth, which are diametrically oppoſite one to the other : that is, two Places, whoſe Difference of Latitude and Longitude, is each 180 Degrees, and ſuch Walk Feet to Feet.

'he *Earth* being encompaſſed with *Water*, whoſe Waſhings urrounding the dry Land, cut out and ſhape many wind- *Bays*, *Creeks*, and *meandring* .*nlets*, giving Terminations to the : Regions of the Earth, and extending it ſelf round them is but one continued Ocean. Wherefore,

'he *Water* is either *Ocean*, *Seas*, *Straits*, *Creeks*, *Lakes*, *Rivers*. *ıys*, &c.

. The *Ocean*, is a general Collection or Rendezvouz of *'aters*.

. The *Sea*, is a Part of the Ocean, to which we come ıgh ſome Strait; as the *Mediteranean* and *Baltic Sea*.

. *A Strait*, is a narrow part of the Ocean, lying betwixt Shoars, and opening a way into ſome Sea; as th *Straits 'ibralter*, that lead into the *Mediteranean Sea*; and the ', which leadeth into the *Baltick-Sea*.

. A *Creek*, is a ſmall narrow part of the Sea, or River goeth up but a little way into the Land.

. A *Bay* is a great Inlet of the Land, as the *Bay of Biſcay* the *Bay of Maxico*: otherwiſe a Bay is a Station, or Road hips to anchor in.

. A *River*, is a ſmall Branch of the Sea, flowing into the l, courting the Banks, whilſt they their Arms diſplay, to ace her ſilver Waves.

. A *Lake*, is that which continually retains and keeps r in it; as the Lake *Zaire* in *Africa*, and Lake *Nicurgua* in *ica*.

. A *Gulf*, is an Inlet of the Land, deeper than a Bay, as *ulf* of *Venice*, the *Gulf of Florida*; in which are ſwift *nts*.

Of the Names of the Ocean.

. The *Ocean*, according to the four Quarters, had four es; as the *Eaſtern* or *Oriental Ocean*, the *Weſtern* or *Oc- al Ocean*, the *Northern*, or *Septentrional*, and the *Southern ridional Ocean*. But beſides theſe, it hath other particular es according to the Continent it boundeth, and the Na- f the Sea. As it lies extendeth towards the Eaſt, it's l the *Chinean Sea*, from the Adjacent Country of *China*: rds the South, it's called *Oceanus Indicus*, or the *Indian-* where it waſheth the Coaſt of *Perſia*, it's called *Mare um*: In like manner *Mare Arabicum* from *Arabia*; and ſo rds the Weſt, it's the *Ethiopean Sea*.

Then

14. A *Continent*, is a great Quantity of Land, not divid by the Sea, wherein are many Kingdoms, and Countries co joined : as *Europe*, *Aſia*, and *Africa* in one Continent, and *merica* is another.

15. An *Iſland*, is a part of the Earth that is environed compaſſed round by *Water*; as *Great-Britain*, and alſo *Irela* *&c* are Iſlands.

In *Continents*, and *Iſlands*, are theſe Parts obſervable, *Peninſula*, *Iſthmus*, and *Promontory*.

16 *Peninſula*, is ſuch a Part of Land as is almoſt enviro round with Water, and is joined with the Land by an *Iſth* as the *Morea* in the *Levant*.

17. An *Iſthmus*, is a norrow Neck of Land between two which joineth the *Peninſula* to the *Continent*; as *Corinth* in *Gr*

18. A *Promontory* is a High Hill, Mountain, or Cap Land that ſhooteth it ſelf into the Sea; as *Cape de Verde*, the Cape of *Good Hope* in *Africa*.

19. A *Place* in reſpect to the *Heavens*, is either Eaſt, W North or South.

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And thoſe are Weſt which lie Weſterly of the ſaid Merid or towards the Setting of the Sun.

Thoſe Places are properly North, which lie betwixt th quator and the Artic Pole.

And thoſe Places are South, which lie betwixt the Æ tor and the Antartic Pole.

The Antients have divided the Inhabitants of the E into *Poriæci*, *Antiæci*, and *Antipodes*.

20. The *Periœci*, are ſuch as live under the ſame Parallel in oppoſite points of it; that is, they are in the ſame Lati but their Difference of Longitude is 180 Degrees.

21. The *Antiœci*, are ſuch as have the ſame Meridian, equally diſtant from the Æquator, but the one North, an other South: that is; Two Places in one Longitude, and equal in Latitude; one in North, and the other in South.

22. The *Antipodes* are ſuch as Inhabit two Places o Earth, which are diametrically oppoſite one to the ot that is, two Places, whoſe Difference of Latitude and Lo tude, is each 180 Degrees, and ſuch Walk Feet to Feet.

The *Earth* being encompaſſed with *Water*, whoſe Waſhings in ſurrounding the dry Land, cut out and ſhape many winding *Bays*, *Creeks*, and *meandring Inlets*, giving Terminations to the Four Regions of the Earth, and extending it ſelf round them all, is but one continued Ocean. Wherefore,

The *Water* is either *Ocean*, *Seas*, *Straits*, *Creeks*, *Lakes*, *Rivers*, or *Bays*, &c.

23. The *Ocean*, is a general Collection or Rendezvouz of all *Waters*.

24. The *Sea*, is a Part of the Ocean, to which we come through ſome Strait; as the *Mediteranean* and *Baltic Sea*.

25. A *Strait*, is a narrow part of the Ocean, lying betwixt two Shoars, and opening a way into ſome Sea; as th *Straits* of *Gibralter*, that lead into the *Mediteranean Sea*; and the *Sound*, which leadeth into the *Baltick-Sea*.

26. A *Creek*, is a ſmall narrow part of the Sea, or River that goeth up but a little way into the Land.

27. A *Bay* is a great Inlet of the Land, as the *Bay of Biſcay* and the *Bay of Maxico*: otherwiſe a Bay is a Station, or Road for Ships to anchor in.

28. A *River*, is a ſmall Branch of the Sea, flowing into the Land, courting the Banks, whilſt they their Arms diſplay, to embrace her ſilver Waves.

29. A *Lake*, is that which continually retains and keeps Water in it; as the Lake *Zaire* in *Africa*, and Lake *Nicurgua* in *America*.

30. A *Gulf*, is an Inlet of the Land, deeper than a Bay, as the *Gulf* of *Venice*, the *Gulf of Florida*; in which are ſwift *Currents*.

Of the Names of the Ocean.

31. The *Ocean*, according to the four Quarters, had four Names; as the *Eaſtern* or *Oriental Ocean*, the *Weſtern* or *Occidental Ocean*, the *Northern*, or *Septentrional*, and the *Southern* or *Meridional Ocean*. But beſides theſe, it hath other particular Names according to the Continent it boundeth, and the Nature of the Sea. As it lies extendeth towards the Eaſt, it's called the *Chinean Sea*, from the Adjacent Country of *China*: Towards the South, it's called *Oceanus Indicus*, or the *Indian-Sea*, where it waſheth the Coaſt of *Perſia*, it's called *Mare Pacificum*: In like manner *Mare Arabicum* from *Arabia*; and ſo towards the Weſt, it's the *Ethiopean Sea*.

Then the *Atlantic Ocean*, from *Atlas*, a Mountain in *Africa*: But near to *America*, it's called by the *Spaniards*, *Mar. del Nort*; And on the other ſide of *America*, it's *Mar-del Zur*, or *Mare Pacificum*.

Where it toucheth upon *Spain*, it's *Oceanus Hiſpanicus*, by the *Engliſh*, the Bay of *Biſcay*: Between *England* and *France*, it's called the *Engliſh Channel*: Between *England* and *Ireland* the *Iriſh Sea*, or St. *George's Channel*: Between *England* and *Holland*, by ſome the *Germany*, but rather the *Britiſh Ocean*: Northward of *Scotland*, it's called *Mare Caledonium*: More Northerly, it's the *Hyperborean* or *Frozen Sea*: More Eaſterly, it's the *Tartarean Sea*, or *Schythian Ocean*, &c. Thus for the Names of the Ocean. Next,

Of the Names of the Seas.

32. The *Baltic Sea*, by the *Dutch* the *Ooſt Zea*, lying between *Denmark*, *Sweden*, and *Germany*, whoſe Entrance is called the *Sound*: The *Mare Mediterranean*, by the Engliſh the *Straits*; by the Spaniards, *Mar-de-Levant*; the Entrance whereof is called the *Straits of Gibralter*: Then *Pontus Euxinus*, or the *Black Sea*; to which joins *Meotis Palus*, now *Mar-del Zabecke*: Then the *Caſpian*, or *Hercanean-Sea*: Then the *Arabian Gulf Mare Rubrum*, or the *Red-ſea*: And the *Perſian Gulf*, or *Gulf de Elcatiff*, &c.

Of the Diviſion of the Earthly Globe.

33. The Globe of the Earth (as was ſaid before in *Def.* 13.) is divided into Four Parts, *viz. Europe*, *Aſia*, *Africa*, *America*,

34. *Europe* is bounded towards the North by the *Northern Ocean*, or *Frozen Sea*; on the South by the *Mediterranean Sea*, lying betwixt it and *Aſia*; on the Eaſt with the River *Tanais*: and on the Weſt by the Weſtern, or *Atlantic Ocean*; whoſe Chief Provinces are,

Poland,
Denmark,
Portugal,
Greece,
Muſcovia,
Germany,
Italy,
Dalmatia,
Sweden.
France,
Hungary,
Romania,
Norway,
Spain,
Scalvonin,
Part of *Tartaria.*

The Principal Iſlands are,

Great Britain,
Corſica,
Ireland,
Candia,
Sardinia,
Negropont,
Sicily,
Cyprus.

35. *Aſia*, is bounded in the North with the Northern and *Tartarian Ocean*; in the South with the *Arabian Gulf*, or *Red Sea*; on the Eaſt with the *Indian Ocean*; and on the Weſt with the River *Tanais.*

The chief Regions are,

Turky in *Aſia*, *Arabia*, *Tartaria*, *Perſia*,
Anatolia *Meſopotamia*, *Aſſyria*, *Chaldea.*
Syria, *Armenia*, *Paleſtina*, *Georgia*,
Media, *Parthia*, *China*, *India*,

The principal Iſlands are,

Japan, *Sumatra*, *Borneo*, &c. in the *Oriental Ocean.*
Cyprus, *Rhodes*, in the *Mediterranean.*
Metellino, *Scio*, *Samos*, &c. in the *Archipelagus.*

36. *Africa* is bounded on the North with the *Meditterranean* on the Eaſt with the *Red-ſea*, on the South with the *Æthiopean* or *Southern Ocean*, and on the Weſt with the *Atlantick Ocean.*

The Principal Provinces are,

Ægypt, *Barbary*, *Billedulgerid.*
Deſarts of *Sarra*, *Negroland*, *Æthiopia*, or *Abyſſine.*
Nubia, *Monomotapa.*

Its Iſlands are,

The *Canary* Iſlands, *Cape de Verde* Iſlands,
The Iſles of *Azores*, *Madera* Iſlands.
St. *Thomas* *Madagaſcar*, or St. *Lawrence.*
Maltha, in the *Mediterranean.*

37. *America*, is bounded on the North with the Northern *Ocean*, on the Eaſt with the *Atlantick Ocean*, on the South with the *Magellantick-ſea*, and on the Weſt with the South Sea, or *Mar del Zur*: It's divided into two Parts, *viz.* *Mexicana*, and *Peruana.*

Mexicana, or *North America* hath theſe Provinces;

New-Spain, *Terra Florida*, *Carolina*, *Virginia*, and
Maryland, *Penſilvania*, *New-Jerſey*, *New-York*,
New-England, *New-France*, *Greenland*, whether Continent or Iſland is not yet known.

The chief Iſlands of *Mexicana* are,

Iſland, or *Ice-land*, *California*, *New-found-land*, *Burmudus.*

Paruana or *South-America*, hath theſe Provinces;

Terra magellanica, *Brazilla*, *Chili*, The *Amazons*, *Guianea*, *Peru*,
Panama, *Carthagena*, *Peraguay*, or *Rio-de-la-Plata.*

The Principal Iſlands of *Paruana* are,

Hiſpaniola, *Cuba*, *Jamaica*, *Port-Rico*, *Berbadoes*, and the reſt of the *Carribbee-Iſlands*, &c.

Moluque Iſlands, *Java-Major*, *Java* the leſs, and many other Iſlands in the *Eaſt Indies.*

Having deſcribed the Lines and Circles, and the Parts belonging to the *Terreſtial Globe*, the Uſes of all take in the following Problems.

Problem 1. *To find the Latitude of any Place upon the Globe.*

The Rule. Bring the propoſed Place juſt under the *Braſs Meridian*; and note what Degree (on the ſaid Meridian) ſtands againſt it, which is the Latitude thereof. Or thus,

With a pair of Compaſſes, take the neareſt Diſtance from the propoſed Place (on the Globe) to any Parallel of Latitude, and lay it on the graduated or firſt Meridian, from the ſaid Parallel, the ſame way the propoſed Place lyeth from it, the other Foot ſheweth the Latitude required.

Example. *Let it be required to find the Latitude of the* Lizard *in* England.

Turn the Body of the Globe till the *Lizard* be juſt under the Braſs-Meridian, and you'll find 50 Deg. right againſt it; which is the Latitude of the *Lizard*. Or thus,

Take the neareſt Diſtance (on the Globe) from the *Lizard*, to a Parallel of Latitude, apply it to the graduated Meridian, and it ſheweth the Latitude 50 Degrees as before.

Note; All thoſe Circles on the Globe, which are parallel to the Æquator, are called Parallels of Latitude.

Problem 2. *To find the Longitude of any Place on the Globe.*

The Rule. 1. Turn (as before) the Globe till the propoſed Place lie juſt under the Braſs Meridian, and there keep it ſteady.

2. Then obſerve what Degreee of the Æquator lieth under the Braſs Meridian, and that's the Longitude required.

Example. *I demand the Longitude of the* Lizard *in* England?

Bring the *Lizard* under the Braſs Meridian, and then the Braſs Meridian cutteth the Æquator in 19d. 56m. the Longitude required.

Note, The Globes formerly made in *England* begun Longitude at the Meridian of the Iſland of St. *Michael*, one of the Iſles of the *Azores*; which is Weſt from the Meridian of *London*, (according to the *Mariners Compaſs Rectified*,) 25d. 20m.

And accordingly the *Lizard*'s Longitude is 5d. 24m. Weſt from *London*: This Difference in the Longitude of Places, is occaſioned by the different beginnings of Longitude by ſeveral Authors, which the Student is deſired to conſider.

Problem 3. *To find the Diſtance of any two Places on the Globe.*

The Rule. 1. Lay the beginning of the Degrees on the Quadrant of Altitude, upon one of the propoſed Places, and count how many Degrees on it are contained between both Places, which is the Diſtance required.

2. Thoſe Degrees being multiply'd by 60, the Product is the Diſtance in Minutes, Or thus,

Take the Diſtance between the two Places with a pair of Compaſſes, then meaſure that Diſtance on the Æquator, counting the Degrees intercepted between both Feet, and it will ſhew the Diſtance required.

Note; The Diſtance found by this Problem, is the ſhorteſt Diſtance: or their Diſtance in the Arch of a Great Circle, which is leſs than their Diſtance in the Rumb, leading from one to the other; except both Places lie under one Meridian, or in the Æquator.

Example. *I demand the Diſtance between the* Lizard *and the Iſland* Berbadoes?

If you lay the Edge of the Quadrant of Altitude on both Places, and the beginning of the Degrees of it on one of the Places, you will find on the Quadrant of Altitude 56 Degress intercepted between them, which is the Diſtance; and being multiplied by 60, is 3360 Miles or Minutes.

Problem 4. *To find the Angle of Poſition of Places; that is, the Angle the Arch of a Great Circle paſſing through two given Places makes with the Meridian of either of them.*

The Rule. 1. Rectifie the Body of the Globe to the Latitude of one of the given Places.

2. Bring the ſame Place under the Braſs Merididian, and there ſtay the Body of the Globe.

3. Screw the Quadrant of Altitude faſt to the Braſs Meridian, right over the ſaid Place.

4. Then lay the graduated Edge of the Quadrant of Altitude to the other place, and the ſaid Edge will cut the Horizon in the Degree of Poſition required.

Example. *Let it be required to know the Angle of Poſition of* Berbadoes *from the* Lizard.

1. Bring the *Lizard* to the Braſs Meridian, and there ſtaying the Body of the Globe, you will find the Latitude of the *Lizard* to be 50 Degrees.

2. Move the Braſs Meridian (keeping the Body of the Globe fixed as before) higher or lower until 50 Degrees on it do cut the Horizon (on the North ſide thereof, then is the Globe rectified to the Latitude of the *Lizard*: The like you muſt do in Rectifying the Globe for any other Place or Latitude.

3. Screw the Quadrant of Altitude to 50 Degrees on the Braſs-meridian, (which is juſt over the *Lizard*, if the Globe be not turned from it's Poſition as in the firſt ſtep hereof) and turn the graduated Edge of it to *Berbadoes*, the ſaid Edge will point on the Horizon to 71d. 30m. South Weſterly; which is the Angle of Poſition of *Berbadoes* from the *Lizard*; that is, the Angle, the Arch of a great Circle paſſing through or over the two Places, makes with the Meridian of the *Lizard*, which is not the Rumb, leading from the firſt to the ſecond: For, if you rectify the Globe to the Latitude of *Berbadoes*, and ſo proceed as before directed, you will find the Angle of Poſition to be 37d. 30m. North-Eaſterly, the Poſition of the *Lizard* from *Berbadoes*, which is 34 Degrees leſs than the Poſition of *Berbadoes* from the *Lizard*; whereby it appears neither of theſe are the true Rumb or Point of the Compaſs leading from one to another. For you are to *Note*;

1. That the Rumb-lines or Points of the Compaſs, make equal Angles with all Meridians on the Globe.

2. That an equal Segment, or part of the ſaid Rumb, changeth or altereth the Latitude in all Places equally.

3. That the Rumb Lines, tho' continued never ſo far, do not paſs through the Poles, but wind about them till they loſe themſelves.

4. Theſe Rumb-Lines are repreſented upon the Globe by thoſe Spiral Lines, that you ſee are 32 in Number, meeting in a Center, where there is a *Flower-de-Luce* pointing to the North; from thence they run winding about the Globe, and continue inclining towards the Pole, where they ſeem confuſed.

Problem 5. *Two Places being given; to find their Rumb or Courſe of Bearing, or Sailing from one to another.*

The Rule. 1. Having found the two Places on the Globe, ſee what Rumb Line paſſes through both of them, and that is the Rumb or Courſe from one to another.

2. If no Rumb Line paſs through both places, then look what runneth Parallel to both Places, and that is the Rumb or Courſe from one to another.

Examp.

Example 1. *I demand the Courſe from the* Lizard *to* Cape Cod *in* New England.

On the Globe you will find theſe Places to lie on the W. by S. and E. by N. Rumb-Line, and therefore the Courſe from the *Lizard* to Cape *Cod*, is W. by S. and conſequently from the laſt to the firſt, E. by N.

Examp. 2. *I demand the Courſe from the* Lizard *to I.* Berbadoes?

Here is no Rumb-Line on the Globe paſſing thro' them. wherefore look for a Rumb to which the Place lies moſt parallel, and you'll find it S.W.$\frac{1}{2}$W. the Courſe from the *Lizard* to *I. Berbadoes*; and N E. $\frac{1}{2}$ E. from *I. Berbadoes* to the *Lizard*.

Problem 6. *Courſe and Diſtance ſailed being given; to find the Difference of Latitude and Difference of Longitude.*

The Rule 1. Make a ſmall Mark on that Rumb-Line (which is the given Courſe) in the Latitude of the Place you ſail from, and bring that Mark to the Braſs Meridian, which cuts the Equator in its Longitude.

2. Take the Diſtance ſailed from the Equator, and lay it on the ſaid Rumb, from the foreſaid Mark; at the Termination therefore make another Mark.

3. Then Bring this Second Mark to the Braſs Meridian, there is the Latitude of that Place; and then the Meridian cuts the Equator in the Longitude of it.

4. Having the Latitude and Longitude of thoſe two Places mark'd in the Rumb-line by Subtraction you may find their Difference of Latitude and Difference of Longitude, and it's done.

Examp. *Suppoſe a Ship ſails* S W. *by* W. 200 *Leagues, or* 10 *Degrees from the* Lizard: *I demand her Difference of Latitude, and Difference of Longitude: or what Latitude and Longitude ſhe is in?*

1. I make a Mark on the S W by W. Rumb, juſt under 50 Degrees, (the *Lizards* Latitude) and then the Meridian cuts the Equator in 357 Degrees, the Longitude of that Mark.

2. Take 10 Degrees from the Equator, and lay it on the S. W by W Rumb, from the firſt Mark to a Second Mark.

3. Bring this Second Mark to the *Braſs-Meridian*, and there the Latitude of it, is 44d. 50m. the Latitude the Ship is in, and in the Equator the Longitude of it is 344d. 15m. and by Subtraction the Difference of Latitude is 5d. 10m and Difference of Longitude required is 12d. 45m. But here you muſt note;

That the Diſtance ſailed intirely taken and laid on the Rumb, is the Diſtance in the Arch of a Great Circle, and not really in the Rumb; for the Diſtance in the Great Circle is always leſs than the Diſtance in the Rumb; wherefore the better way will be, to take 1, 2, 3, (or ſome ſmall Number of) Degrees of the *Equator*; and run that Diſtance (in the Compaſſes) over upon the *Rumb-Line*, from the Firſt Mark to the Second: and in ſo doing, the Diſtance is more truly laid than by taking it at once.

Problem VII. *Both Latitudes and Courſe given; to find the Diſtance and Difference of Longitude.*

The Rule. 1. Turn the Body of the Globe till the given Rumb doth cut the Braſs-Meridian in the Latitude you depart from, and there make a Mark on the Rumb, and at the ſame time ſee what Degrees of the Equator is cut by the Meridian; for that is the Longitude of this Mark.

2. Turn the Body of the Globe till the ſame *Rumb* cuts the Meridian in the Latitude of the Second Place, and there make another Mark on the Rumb; then ſee what Degree of the Equator is cut by the Meridian, which is the *Longitude* of the Second Mark; and the leſſer Longitude ſubtracted from the greater, gives the Difference of Longitude required.

3. The Diſtance between the two Marks on the Rumb-Line being meaſured (according to the *Note* in the laſt *Problem*) on the *Equator*, gives the Diſtance of the two Places.

Example. *If a Ship ſails S. W. by W. from the* Lizard, *till by Obſervation ſhe be in Latitude* 44^d. 50*m. North; I demand her Diſtance ſailed, and what Longitude ſhe is in?*

1. When you bring the S W. by W. Rumb to cut the Meridian in 50 Degrees, the *Lizard's* Latitude, and make a Mark on the Rumb there, then the Meridian cuts the Equator in 357 Degrees, the Longitude of that Mark.

2. Turning the Globe till the S W. by W. Rumb cuts the Meridian in 44d. 50m. the Latitude of the Second Place, and making there a Mark on the Rumb: then the Meridian cuts the Equator in 344d. 15m the *Longitude* of the Second Mark: And therefore the *Difference of Longitude*, is 12d. 45m. Weſt; which being ſubtracted from the Longitude of the *Lizard*: 20d. 00m. the Remainder is 07d. 15m. the Longitude the Ship is in.

3. Take 2 Degrees from the Equator, and run over that Diſtance in the Compaſſes upon the Rumb, from the Firſt

Mark to the Second; and it's five times, which is 10d. or 200 Leagues, the Diſtance ſailed on that Rumb.

Problem 8. *Having the Latitude and Longitude the Ship is in given; to find the Place where the Ship is in on the Globe.*

The Rule 1. Bring the Longitude to the Braſs Meridian, and there ſtay the Body of the Globe.

2. Where the given Latitude cuts the Globe make a Mark on the Body of the Globe, which Mark is the Place of the Ship at that Time.

Example. *If a Ship ſails from the* Lizard, *and after ſome time is in Latitude* 44d. 50m. *and Longitude* 9d. 45m. *I demand the Place of the Ship on the Globe?*

1. Bring 9d. 45m. on the Equator to the Braſs Meridian, and there ſtay the Globe.

2. Juſt under 44d. 50m. on the Braſs Meridian, make a Mark on the Body of the Globe, and that is the Place of the Ship at that Time.

Section III. *The Deſcription of the* Cœleſtial Globe.

THE *Cœleſtial Globe* repreſents that Glorious Canopy, ſo richly embroidered and beſet with thoſe Sparkling Diamonds, that upon the Dusky Cheeks of the Night hang as a rich Jewel in an *Ethiopean's* Ear; having upon it's Convexity artificially placed all the Stars, correſpondent to their natural ſituation in the Concavity of that *Orb*, we call the *Starry Heaven.*

2. The Appurtenances belonging to this are the ſame with thoſe belonging to the *Terreſtial Globe*; and being before deſcribed in *Section* 1. of this Chapter, I refer you to it.

3. On the Body of the Globe, beſides the Conſtellations of the *Stars*, there are drawn divers Circles; as the *Equinoctial*, *Ecliptic*, *Colures*, *Meridians*, and *Circles of Longitude*; all theſe are called Great Circles: the Leſſer Circles are the *Tropics*, *Polar Circles*, and *Parallels of Declination.*

4 The *Equinoctial* in this, is the ſame with the Equator in the *Terreſtial Globe*, and in the ſame manner divided; and numbred from the Left-hand towards the right with 10, 20, 30, *&c.* to 360 Degrees.

The Poles of the Equinoctial are alſo called the Poles of the World, and are repreſented by the Two Wires on which the Body of the Globe turneth.

5. The *Ecliptic* is a Great Circle which croſſeth the Equinoctial in two oppoſite Points; the beginning of *Aries*, and *Libra*; it's divided into twelve (equal Parts) called Signs, each containing 30 Degrees, and figured from the left Hand towards the right, 10, 20, 30; then 10, 20, 30, *&c.* having the Figure, Character, and Names of the Sign, as followeth:

Aries	♈	Northern Signs	*Libra*	♎	Southern Signs.
Taurus	♉		*Scorpio*	♏	
Gemini	♊		*Sagitarius*	♐	
Cancer	♋		*Capricornus*	♑	
Leo	♌		*Aquarius*	♒	
Virgo	♍		*Piſces*	♓	

This Circle with its Figures and Characters, are on both Globes; but the Cœleſtial hath the Image and Name of the Signs, which the Terreſtial hath not.

Under this Citcle the Sun moves in his Annual Courſe; but the reſt of the Planets have their Deviations from it; for which Reaſon *Aſtronomers* aſſign'd Eight Degrees on each Side the Ecliptic, making the whole Latitude to be 16 Degrees, breadth is called the Zodiac.

The *Zodiac*, is not drawn on the Globe, only imagined by two Circles parallel to the Ecliptic, at Eight Degrees diſtance which from it on each ſide thereof.

The *Poles of the Ecliptic*, are two oppoſite Points, each 23d. 30m diſtant from its Correſpondent *Pole of the World*; there the Circles of Longitude meet, and near it, is writ *Polus Eclipticæ*.

6. The *Meridians* are the ſame as was ſaid in the *Terreſtial Globe*, only with this Difference, on this they are drawn through every 30th Degree of the Equinoctial, on that through every 15 Degree of the Equator; in both they all meet in the Poles of the World.

7. The *Colures*, or two Meridians, cutting each other at Right Angles in the Poles of the World, dividing the Equinoctial, and Ecliptic into 4 equal Parts; the one paſſeth by the beginning of *Aries* and *Libra*, two *Equinoctial Signs*, therefore called the *Equinoctial Colure*: and on the Globe it is divided into Degrees, numbred from the Equinoctial both ways 10, 20, 30, *&c.* ending in 90 at each Pole of the World; it hath theſe Words near it, *Colurus Equinoctiorum.*

The other paſſeth through the Beginning of *Cancer* and *Ca-*

pricorn, two *Solſtitial Signs*, therefore called the *Solſtitial Colure*: this paſſeth through the Poles of the World, and Poles of the Ecliptic; its diſtinguiſhed on the Globe by theſe Words, *Colurus Solſtitiorum*.

8. The *Horizon*, is a Great Circle 90d. diſtant from the Zenith, and Nadir, cutting all Azimuth Circles at Right-angles, and divideth the World into two equal Parts, the upper and viſible Hemiſphere, the lower and inviſible; it's repreſented by the upper Side of the Wooden Frame, on which is a double Kalendar, of Months and Day, according to the Old and New Stile, with the Winds or points of the Compaſs, and a Circle of Signs and their Degrees.

The Zenith and Nadir, are two Points diametrically oppoſite, and they are the Poles of the Horizon. The Zenith is the *Vertical Point*, or Point over our Head; the Nadir is directly oppoſite thereto.

9. The *Azimuths* or *Vertical Circles*, are Great Circles interſecting each other in the Zenith and Nadir, and cutting the Horizon at Right Angles: Theſe Circles are not drawn on the Body of the Globe, but are repreſented by the Quadrant of Altitude, when it's ſcrew'd in the Zenith.

10. *Circles of Longitude*, are Great Circles interſecting each other in the Poles of the Ecliptic, and cut it at Right-Angles: Theſe are repreſented by the Quadrant of Altitude when it is ſcrew'd over the Poles of the Ecliptic; and on the Body of ſome Globes, 12 of theſe Circles are drawn, paſſing through the Beginning of the Twelve Signs,

Thus much for the Great Circles. We paſs on to

The Deſcription of the Leſſer Circles.

Leſſer or Small Circles, are thoſe which divide the Globe into two Unequal Parts, and are Parallel to ſome Great Circle, therefore called *Parallel Circles*, and are of three kinds, *viz. Parallels of Declination*, *Parallels of Altitude*, and *Parallels of Latitude*.

11. *Parallels of Declination*, are Parallel to the Equinoctial, imagined to paſs through every Degree and Minute of the Meridian, between the Equinoctial, and each Pole of the World; and are the ſame with the Parallels of Latitude on the *Terreſtial Globe*.

The *Tropicks* and *Polar-Circles*, are Parallels of Declination, and the ſame as before in the Deſcription of the *Terreſtial Globe*.

12. *Almicanthers*, or *Parallels of Altitude*, are Parallel to the Horizon imagin'd to paſs through every Degree and Minute of the Meridian of a Place, between the Horizon and the Zenith of that Place : Theſe are deſcribed by the Diviſions on the Quadrant of Altitude in its Motion about the Body of the Globe, when it is ſcrewed in the Zenith of any Place.

13. *Parallels of Latitude*, are ſmall Circles parallel to the *Ecliptic*, imagined to paſs through every Degree and Minute of the Colures between the Ecliptic and the Poles thereof. Theſe are repreſented by the Diviſions of the Quadrant of Altitude in its Motion round the Body of the Globe, when it is ſcrew'd over the Poles of the Ecliptic.

Having deſcribed the imaginary Circles of the *Cæleſtial Globe*, we proceed now to the Deſcription of the Stars, thoſe glorious Diamonds, ſparkling in the immenſe Expanſion of the Firmament, encirling the Terreſtial Orb at unmeaſurable Diſtance, which for Multitude ſeems innumerable, yet the greateſt and more viſible may be numbred and named: And for this Purpoſe *Aſtronomers* (for Order and Method ſake) have reduced many Stars into one *Image* or *Conſtellation*, the better to know where to ſeek them ; and being found how to expreſs them.

14. the Number of Conſtellations now drawn on the Body of the *Cæleſtial Globe*, are 66, and are as followeth.

The Northern Conſtellations 23, *viz.*

	Stars
1. *Urſa Minor*	9
2. *Urſa Major*	33
3. *Draco*,	36
4. *Cepheus*	11
5. Bootes	22
6. *Corona Borealis*	8
7. *Hercules*	30
8. *Lyra*	10
9. *Olor*, aut *Cygnus*	17
10. *Coſſiopea*	23
11. *Perſeus* and *Caput Meduſa*	27
12. *Auriga*	24
13. *Serpentarius*	23
14. *Serpens*	14
15. *Sagitta*	5
16. *Aquilla*	9
17. *Antionius*	7
18. *Delphinus*	10
19. *Equiniculus*	5
20. *Pegaſus*	23
21. *Andromeda*	23
22. *Triangulum*	3
23. *Coma Berenices*	11
In all	383

The Zodiacal Conſtellations are 12, *viz.*

	Stars		Stars
1. *Aries*	16	7. *Libra*	10
2 *Taurus*	32	8. *Scorpio*	26
3. *Gemini*	24	9. *Sagittarius*	29
4. *Cancer*	16	10. *Capricornus*	21
5. *Leo*	33	11. *Aquarius*	34
6. *Virgo*	39	12. *Piſces*	34
		In all	314

The Southern Conſtellations are 30, *viz.*

	Stars		Stars
1. *Cetus*	26	17. *Columbus*	10
2. *Orion*	39	18. *Piſces Auſtrinus*	11
3 *Flumen Eridanus*	43	19 *Grus*	13
4. *Lepus*	13	20. *Phœnix*	12
5. *Canis major*	13	21. *Indus*	12
6 *Canis minor or Canicula*	2	22. *Pavo*	16
7. *Argo Navis*	42	23. *Avis Indica Touchan.*	7
8. *Robur Carolinum*	11	24. *Apus muſca*	3
9. *Hydra*	27	25. *Chameleon*	10
10. *Crater*	8	26. *Triangulum Auſtralis*	5
11. *Corvus*	7	27. *Piſces Volans*	7
12. *Centaurus*	30	28. *Derado*	7
13. *Lupus*	22	29. *Apous Anſer, Americanus*	10
14. *Croſero or the Croſiers*	5	30. *Hydrus Serpens Auſtrina*	10
15. *Ara, or the Alter*	8		
16. *Corona Auſtrina*	10	In all	439

There is added by Sir *Charles Scarborough*, a Conſtellation called *Cor Caroli*, being one Star in a Crowned Heart, lying between *Urſa Major* and *Coma Berenicis*: So that the Conſtellations now pourtray'd on the Globe are *66*, containing 1136 Stars, beſides many that are unformed, making in all more than 1300 Stars, which are diſtinguiſhed into *Six Degrees of Magnitude, or Bigneſs*: The biggeſt and brighteſt are called *Stars of the Firſt Magnitude*; thoſe next inferior in bigneſs and brightneſs, are *Stars of the Second Magnitude*, &c. unto *Stars of the Sixth Magnitude* Theſe ſeveral Magnitudes are expreſſed on the Globe in ſeveral ſhapes, as may be ſeen in a little Table placed on the Globe, intituled *Stellarum Magnitudines.*

Section IV. *The Uſe of the* Cæleſtial Globe.

BEfore working any Problem on this Globe I hold it neceſſary to explain ſeveral Words of Art uſed in *Aſtronomy*, and *Geography*, and are in theſe following Definitions.

1. *Altitude*, is an Arch of an Azimuth Circle, contained between the Horizon and any Parallel of Altitude. It's counted on the Braſs Quadrant of Altitude, which repreſents any Azimuth Circle on the Globe.

2. *Aſcenſion*, is the Riſing of the Sun or Star, or any part of the *Equinoctial* above the Horizon; and *Deſcenſion*, is the Seting thereof.

3. *Right Aſcenſion*, is an Arch of the Equinoctial intercepted between the beginning of *Aries*, and any Meridian, and counted according to the Order and Succeſſion of the Signs; Or, 'tis that Degree and Minute of the Equinoctial (counted as before) which cometh to the Meridian with the Sun, Star, or with any Point of the *Heavens*.

4. *Oblique Aſcenſion*, is that Degree and Minute of the Equinoctial (counted as before) which riſeth with the Center of the Sun, or Star, or with any Point of the Heavens: And *Oblique Deſcenſion* is the Setting thereof.

5. *Aſcenſional Difference*, is the Difference between the *Right* and *Oblique Aſcenſion*, or *Deſcenſion*: Or it is the Space of Time the Sun Riſeth, or Setteth before, or after Six of the Clock.

6. *Amplitude*, is an Arch of the Horizon comprehended between the true Eaſt and Weſt Points of it, and the Center of the Sun, or Star, at their Riſing, or Setting.

7, *Azimuth*, is an Arch of the Horizon contained between the Meridian of the Place and any other Azimuth Circle: Or contained between the *Prime Vertical*, and any other Azimuth Circle,

8. *Declination*, is an Arch of a Meridian, comprehended between the Equinoctial and the Center of the Sun, or Star, or any Point of the Heavens: It's North Declination on the North ſide of the Equinoctial, but South Declination when on the South Side thereof. And it is counted on the Braſs Meridian on the Globe, and on the Equinoctial Colure.

9. *Hour of the Day or Night*, is an Arch of the Equinoctial, contained between the Meridian of the Place, and another Meridian paſſing through the Center of the Sun at any time. This is counted on the Braſs Hour Circle, which is divided into

the 24 Hours of the Day, and Night; and hath a little Braſs Index pointing to them as the Globe is turned about: Or it is counted on the Equinoctial Reckoning 15d. an Hour.

10. *Latitude of a Star*, is an Arch of a Circle of Longitude, contained between the Ecliptic and the Star's Center: This is counted on the Braſs Quadrant of Altitude, when ſcrewed over the Pole of the Ecliptic, for then it repreſents a Circle of Longitude.

11. *Latitude of a Place, or Latitude upon the Earth*, is an Arch of the Meridian of that Place contained between the Equator and that Place: Equal to which is the Height of the Pole (of the World) above the Horizon. This is counted on the Braſs Meridian of the Globe: Or it may be counted on the graduated Meridian on the Body of the Globe.

So that *Latitude* in the *Heavens*, and *Latitude* on the *Earth*, are different things; one being an Arch of a Circle of Longitude and applicable to the Planets (except the Sun, who hath no Latitude) and Stars: The other an Arch of a Meridian, and applicable to Places on the *Earth*.

12. *Longitude in the Heavens*, is an Arch of the Ecliptic, comprehended between the beginning of *Aries*, and that Circle of Longitude which paſſeth through the Center of the Sun, Star, or any Point of the Heaven, and counted according to the Succeſſion of the Signs.

13. *The Place of the Sun, or a Star, with reſpect to the Ecliptic*, is the Sign, and Degree, and Minute of that Sign the Sun or Star is in,

14. *Longitude of the Sun, or of a Star, from the neareſt Equinoctial Point*, is how many Degrees and Minutes the Sun or Star is from the beginning of *Aries*, or *Libra*; either before or after them; which can never be more than 180 Degrees.

15. *Longitude on the Earth*, is an Arch of the Equator, comprehended between the Meridian of any Place, and that Meridian where Longitude takes its beginning

So that *Longitude in the Heavens*, and *Longitude on the Earth* are vaſtly different, one being an Arch of the Ecliptic, the other an Arch of the Equator.

16. *Meridian of a Place*, is that Meridian which paſſeth over the Zenith of that Place; to which when the Sun cometh it's either Noon or Midnight: At the Firſt he is at his higheſt Altitude above the Horizon, and at the laſt, he is at the loweſt Depreſſion for that Day.

In like manner any Star coming to the Meridian of any Place it is at the higheſt Altitude, or loweſt Depreſſion.

Theſe Things being well conſider'd, the following *Problems* will be the better underſtood.

Problem 9. *The Day of the Month given; to find the Sun's Place in the Ecliptic.*

The Rule. 1. Seek the Day of the Month (in either Account according to the *Julian or Gregorian*) as you find them placed in the *Kalendar* on the upper ſide of the Horizon.

2. Right againſt it, in the innermoſt Circle, is the Sign, Degree, and Minute, the Sun ſhall be in that Day at Noon

Example. *The* 8*th* Day *of* January *in the* Julian, *or* 19*th of the* Gregorian Account: *I demand the Sun's Place in the Ecliptic.*

Right againſt the 8th of *January* in the *Julian Kalendar*, in the Circle next within it, it is 29 Degrees of *Capricorn*, in which Sign and Degree the Sun will be the 8th of *January*.

In like manner his Place for *February* the 15th, is 7d. 30m. in *Piſces*.

Problem 10 *How to Rectifie the Globe for any Latitude, and to make it fit for Uſe, at any given Time.*

The Rule. 1. The *Globe* being placed in the Frame, by putting the Braſs Meridian into the two Notches that are in the North and South parts of the Horizon, ſo that the graduated Side thereof be towards the Eaſt, and it reſts in the Notch, that is in the Bottom of the Frame: Move the ſaid Meridian higher, or lower till the given Latitude in it doth juſt touch the upper Part of the Horizon on the North ſide thereof, if North Latitude, but the South ſide when South Latitude.

2. Place the *Braſs Hour Circle* about the Pole, ſo that the Hours of 12 and 12 lie directly over the graduated Side of the Braſs Meridian; and put the little Index on the Axis ſo that it may move about as you turn the Globe; then doth the upper 12 on the *Hour-Circle* repreſent 12 at Noon, and the lower 12 at Midnight; and all the other Figures correſpondent Hours of the Day and Night.

3. By *Problem* 9. Find the Sun's Place according to the given Time; then ſeek the Sun's Place in the Ecliptic on the Body of the Globe, and bring that Degree to the Braſs-Meridian; there ſtay the Globe, and then turn the little Index till it points juſt at the upper 12 in the Hour Circle.

Thus is the Globe Rectified to the given Latitude, and the Hour Circle and Index to the given Time.

Example. *At* London *the* 14th *of* February; *I would have the Globe rectified fit for Uſe.*

1. Move the Braſs Meridian till 51d. 32m. in it toucheth the North Part of the Horizon.

2. By *Problem* 9. The Sun's Place is 6d. 30m. in *Piſces*; which being found in the Ecliptic on the Globe, bring it to the Braſs Meridian, and there ſtaying the Globe turn the little Index to the upper 12 in the Hour Circle; and there ſet it ſo, that it may move with the Globe, and it's done.

Problem 11. *The Day of the Month given; to find the Sun's Declination.*

The Rule. 1. By *Prob* 9. Find the Sun's Place in the Ecliptic.

2. Bring the Sun's Place (in the Ecliptic on the Globe) to the Braſs Meridian, on which and right over the Sun's Place is his Declination required.

Example. *The* 14*th of* February; *I deſire to know the Sun's Declination.*

1. The Sun's Place in the Ecliptic, for the 14th of *February* (found by *Problem* 9.) is 6d. 30m. in ♓.

2. Bring 6d. 30m in ♓ (in the Ecliptic on the Globe) to the Braſs Meridian, and then right over it on the Braſs Meridian is 9d. 10m. which is the Sun's Declination, South Decreaſing. Or thus;

1. With a Pair of Compaſſes take the neareſt Diſtance from the Sun's Place in the Ecliptic 6d. 30m. in ♓, to the Equinoctial on the Globe.

2. Meaſure that Diſtance on the Equinoctial-Colure, and it ſheweth the Declination 9d. 10m. as before.

Problem 12. *The Day of the Month given; to find the Sun's Right Aſcenſion,*

The Rule. 1. As before find the Sun's Place in the Ecliptic by *Problem* 9.

2. Bring the Sun's Place (as directed in *Problem* 11.) to the Braſs-Meridian, look what Degree of the *Equinoctial* is cut by it, and that is the Sun's *Right Aſcenſion* required.

Example. *The* 14*th of* February: *I demand the Sun's Right Aſcenſion?*

1. The 14*th* of *February* his Place in the Ecliptic is 6d. 30m. in ♓ by *Problem* 9.

2. His Place 6d. 30m. of ♓, being brought to the Braſs-Meridian, it cuts the Equinoctial in 338d. 15m. the Sun's Right Aſcenſion.

Problem. 13. *The Latitude of a Place, and the Day of the Month given, to find the Time of the Sun's Riſing, Setting, and his Amplitude.*

The Rule. 1. Rectifie the Globe (by *Problem* 10. fit for Uſe) according to the given Latitude, and given Time.

2. Bring the Sun's Place (in the Ecliptic on the Globe) down to the Horizon on the Eaſt ſide thereof, and then the little Index will point to the Sun's Riſing in the Hour Circle: and the Body of the Globe ſtayed there, look what Degrees of the Horizon (counted from the Eaſt Point thereof) ſtandeth right againſt his Place (in the Ecliptic on the Globe) that is the Sun's Amplitude at his Riſing.

In like manner turn the Globe till you bring the Sun's Place to lie even with the Weſt ſide of the Horizon, ſtaying the Body of the Globe there, then will the Index point to his Setting, and againſt his Place on the Globe ſtandeth his Amplitude (on the *Horizon*) counted from the W. Point thereof.

Example. *The 14th of* February *at* London: *I demand the Time of the Sun's Riſing and Setting, and his Amplitude.*

1. The Globe being Rectified to the Latitude of 51d. 32m. and the Hour Index to 6d. 30m. of ♓, then 'tis Rectified to the given Latitude and given Time.

2 Bring 6d. 30m of ♓, to the Eaſt ſide of the Horizon, and ſtaying the Globe there, the Index points to 6 Hours ¾; that is ¾ after 6 is the Sun's Riſing: And againſt 6d. 30m. of ♓, is 14d. 35m. on the Horizon (from the Eaſt towards the South) which is the Sun's Amplitude at Riſing.

In like manner turn the Globe till you bring 6d. 30m. of ♓, to the W. ſide of the Horizon, and the Index Points to ¼ after 5 which is the Sun's Setting; and in the Horizon you have his Amplitude (the ſame as before) 14d. 35m. from the (Weſt towards the South.) which is the Sun's Amplitude or Setting.

Problem 14. *The Latitude of a Place, and the Day of the Month given; to find the Sun's Oblique Aſcenſion, and Deſcenſion.*

The Rule. 1. Rectify the Globe to the given Latitude, and find the Suns Place in the Ecliptic for the given Time.

2. Bring the Sun's Place in the Ecliptic on the Globe, to the Eaſt ſide of the Horizon, and then ſee what Degree of the Equinoctial is cut by the Horizon, and that is the Sun's Oblique Aſcenſion.

3. In Like manner bring the Sun's Place in the Ecliptic to the Weſt ſide of the Horizon, and it ſheweth his Oblique Deſcen.

Example. *The* 14th *of* February *at* London: *I demand the Sun's Oblique Aſcenſion and Deſcenſion.*

1. Rectifie the Globe to the given Latitude 51d. 32m. according to *Problem* 10.

2. Bring 6d. 30m. of ♓ (the Sun's Place for the 14th of *February*) to the Eaſt ſide of the Horizon, and then it cuts the Equinoctial in 349d. 50m. which is the Sun's Oblique Aſcen.

3. Bring 6d. 30m. of ♓ to the Weſt ſide of the Horizon, it cuts the Equinoctial in 326d. 30m. which is the Sun's Oblique Deſcenſion.

Prob. 15. *The Latitude of a Place, and Day of the Month given; to find the Suns Altitude, and Azimuth at any time of the Day.*

The Rule. 1. Rectifie the Globe and Hour-Index, as before in *Problem* 10.

2. Screw the Quadrant of Altitude in the Zenith; which I call Rectifying the Quadrant of Altitude to the Latitude of the Place.

3. Turn the Globe till the Index point to the given Hour of the Day, and there ſtay the Globe.

4. Move the Quadrant of Altitude till the graduated Edge of it lie juſt on the Sun's Place in the Ecliptic on the Globe, and there ſtay it.

5. Look what Degree on the Quadrant of Altitude is againſt the Sun's Place, and that is the Sun's Altitude.

6. Look what Degree of the Horizon is cut by the Graduated Edge of the Quadrant of Altitude, counted from the North, or from the South, that is, the Sun's Azimuth.

Example. *At* London *the* 17*th of* June, *at 6 of the Clock in the Forenoon*; I *demand the Sun's Altitude and Azimuth*?

1. The Globe being Rectified by *Prob* 10. turn it about till the Hour Index point to *6* in the Morning, and there ſtay the Body of the Globe.

2. Screw the Quadrant of Altitude on 51d. 32m. (on the Braſs-Meridian) which is the Zenith, or *London*'s Diſtance from the Equinoctial.

Note, In ſcrewing the Quadrant of Altitude on the Braſs-Meridian, you muſt put the Screw-Side of the Notch, on the back-ſide thereof, and put it cloſe down, ſo cloſe to it, that the thin Plate may be as near the Body of the Globe as poſſibly you can; yet ſo, as not to obſtruct its moving.

Alſo mind that you ſet the ſloped Edge of the Notch to the Latitude of the given Place.

3. Bring the Graduated Edge of the *Quadrant of Altitude* to 6d. 10m. of ♋, the Sun's Place (for *June* the 17*th*) in the *Ecliptic*, and then on the *Quadrant of Altitude* (againſt it) is 18d. 30m. his Altitude at 6 of the Clock.

4. And the *Quadrant of Altitude* cuts the *Horizon*, in 104d. 50m. from the South Eaſtward, which is the Sun's Azimuth at the ſame Time.

Problem 16. *The Latitude of a Place, the Day of the Month, and Sun's Altitude given; to find his Azimuth and Hour of the Day.*

The Rule. 1. Rectifie the *Globe*, *Hour Index* and *Quadrant of Altitude*, as before.

2. Turn the Body of the Globe, and move the Quadrant of Altitude, till you bring the Sun's Place in the Ecliptic to lie juſt under his Altitude on the Quadrant; there ſtay them both.

3. Then will the Graduated Edge of the *Quadrant* point out the Azimuth in the Horizon from the North, or South; and the Index ſheweth the Hour of the Day.

Example. *At* Berbadoes *the* 14*th of February, in the Forenoon, the Sun's Altitude being* 30*d. I demand his Azimuth, and Hour of the Day?*

1. The Globe being Rectified to the Latitude of *Berbadoes* 13d. 30m. alſo the Hour Index to 6d. 30m. of ♓, the Sun's Place for the 14th of *February*, and the Quadrant of Altitude ſcrewed in the Zenith.

2. Then move the Globe and Quadrant of Altitude, till you bring 30 Degrees on the latter to lie juſt over 6d. 30m. of ♓ in the Ecliptic, and there ſtay them both.

3, Then doth the *Quadrant of Altitude* lie right againſt 72d. in the Horizon, from the South towards the Eaſt, the Sun's Azimuth, which is almoſt E. S. E. ½ E.

4. And then the Hour Index Points to 8 Hours ¾, that is 45m after 8 of the Clock in the Morning.

Problem 17. *The Latitude of a Place, the Day of the Month and Sun's Azimuth given; to find his Altitude, and Hour of the Day.*

The Rule. 1. Rectifie the Globe, Hour Index, and Quadrant of Altitude as before.

2. Turn the Quadrant of Altitude, to the given Azimuth in the Horizon, and there ſtay it.

3. Then bring the Sun's Place in the Ecliptic (keeping the Quadrant of Altitude fixed) to the graduated edge thereof, (which is alſo before ſet to his given Azimuth); and ſtay the Globe there.

4. And then doth the Ecliptic cut the Quadrant in the required Altitude, and the Index ſheweth the Hour of the Day deſired.

Example. *At* Berbadoes *the* 14th *of* February, *the Sun's Azimuth in the Afternoon, being W. S. W.* ½ *W. or* 73*d. South Weſterly: I demand his Altitude and Hour of the Day?*

Anſw. Obſerving the foreſaid Directions, and turning the Globe and Quadrant of Altitude towards the Weſt, you will find the Sun's Altitude to be 30d. and the Hour of the Day 15m. after 3 in the Afternoon.

Problem 18. *The Latitude of the Place, the Sun's Altitude, and Azimuth given; to find his Place in the Ecliptic, and Hour of the Day.*

The Rule. 1. Rectifie the Globe to the Latitude, and ſcrew the Quadrant of Altitude to the Zenith.

2. Turn the Graduated Edge of the Quadrant of Altitude to the given Azimuth in the Horizon, and there ſtay it.

3. Turn the Body of the *Globe*, (without ſtirring the Quadrant out of it's Place) till the Ecliptic cut the Quadrant in the given Altitude; which will then cut the Ecliptic in the Sun's Place required?

4. Then turn the Sun's Place to the Braſs Meridian, and Rectifie the Hour Index to 12.

5. Turn back the Sun's Place to the graduated Edge of the Quadrant (it being in the ſame Place; that is, at the given Azimuth as before) and then the Index will ſhew the Hour of the Day required?

Note; In turning the Globe according to the third ſtep in this Rule, the given Altitude in the Quadrant will cut the *Eclip-*

tic into two ſeveral Signs, and yet the Hour of the Day ſought by the Fourth Step, will be the ſame; ſo that unleſs the Month be given, the Sun's Place cannot be determin'd.

Example. *At* London, *in* October, *the Sun's Altitude being* 20*d. and his Azimuth S. E. or* 45*d. South Eaſterly: I demand his Place in the Ecliptic, and the Hour of the Day?*

Anſwer. The *Sun's Place* is 23d. 30m. in ♎, and its 7m after 9 in the Morning, the 5th of *October* at *London*,: Alſo the Sun's Altitude and Azimuth being the ſame, his Place may be 6d. 30m. in ♓, and the Hour the ſame, the 14th of *February.*

Note; All theſe Problems may be wrought, having the Sun's Declination given, inſtead of the Day of the Month, which may be ſeen in the next Problem.

Prob. 19. *The Latitude of a Place, the Declination, and Altitude of the Sun given, to find his Azimuth, and Hour of the Day.*

The Rule. 1. Rectifie the Globe to the given Latitude, and the Quadrant to the Zenith as before.

2. Bring the Equinoctial Colure to the Braſs Meridian, and then ſet the Hour Index, to the upper 12; which is Rectifiying it when the Declination is given.

3. Move both Globe and Quadrant of Altitude, till the given Altitude on the latter meet with the given Declination in the Equinoctial Colure on the former, and there ſtay them both.

4. Then doth the Quadrant cut the Horizon in the Sun's Azimuth, and the Index ſheweth the Hour of the Day required. Alſo at the ſame time the Braſs-Meridian cuts the Equinoctial in ſo many Degrees (counting from the Colure, allowing 15d. to an Hour) as the required Hour of the Day is, either before or after Noon.

Examp. *At* London, *the Sun's Declination being* 15*d. North, and his Altitude* 19*d.* 30*m. in the Morning: I demand his Azimuth, and Hour of the Day?*

Anſw. The Sun is Eaſt, and the Hour 52m. after 6 of the Clock, or 77d. of the Equinoctial is intercepted between the Colure and Braſs Meridian; which makes 5h. 8m. from Noon, at which time the Sun is Weſt in the Afternoon.

In like manner may any of the preceding Problems be wrought, obſerving theſe following *General Directions.*

1. Count the Latitude on the Braſs Meridian.

2. The Declination on the Colure from the Equinoctial, either Northward or Southward, according to its Name.

3. The Altitude on the Quadrant of Altitude.

4. The Azimuth in the Horizon, from the Braſs Meridian to the Quadrant.

5. And the Hour (from Noon in Degrees) on the Equinoctial, from the Equinoctial Colure to the Braſs Meridian.

Then having any Three of theſe Five given, the other two may be found, which I leave for the Learner's Exerciſe.

Note; All the foregoing Problems, may be wrought on either Globe; but the following only on the *Cœleſtial Globe*.

Prob. 20. *To find the Declination, and Right Aſcenſion of a Star.*

The Rule 1. Bring the given Star to the Braſs Meridian and there ſtay the Globe.

2. Then the Center of the Star cuts the Braſs Meridian in its Declination, counted from the Equinoctial either Northward, or Southward.

3. And the Braſs Meridian cuts the Equinoctial in its Right Aſcenſion, counted from the beginning of ♈ according to the Succeſion of the Signs.

Example. *I demand the Right Aſcenſion, and Declination of* Aldebaran, *or* Oculus Tanti *the Bull's Eye* ?

Anſwer. According to the Direction above, you will find its Right Aſcenſion 65d. 03m. and its Declination near 15d. 55m North.

Problem 21. *To find the Latitude and Longitude of a Star.*

The Rule. 1. Bring the Solſtitial Colures to the Braſs Meridian, that the Pole of the Ecliptic on the Globe may be juſt under 23d. 30m. on the ſaid Meridian, and there fix the Body of the Globe.

2. Screw the Quadrant of Altitude juſt over the Pole of the Ecliptic.

3, Bring the Graduated Edge of the Quadrant to the Center of the Star, and there ſtay it.

4. Then the Star cuts the Quadrant in its Latitude, and the Quadrant cuts the Ecliptic in its Longitude.

Example I *demand the Latitude and Longitude of* Arcturus *a Star of the firſt Magnitude in the Conſtellation* Bootes.

Anſwer. This Star's Latitude is 30d. 57m North, and it's Longitude 20d. 24m. in ♎, or 200d. 24m. from the beginning of ♈; and ſo for any other, as in the following Table.

Stars Names	Magnet.	*Longitude* D M	*Latitude.* D. M.	*Right Aſcen.* D M	*Declination* D. M
Pole-Star, or North-Star ——— ——	2	♊ 26 05	66.30 N	68.00	87.35 N
Laſt in Eridanus Acarnar ———	1	♓ 10.55	59 55 S	21.15	58.55 S
Whales Jaw Cetus	2	♉ 10.29	12.37 S	42.00	02.59 N
Bull's Eye Aldebaran	1	♊ 5.57	5.30 S	65 03	15.55 N
Capella, or Auriga's left Shoulder ——	1	♊ 18.02	22.52 N	74.07	45.41 N
Orion's left foot Regel	1	♊ 13.00	31.10 S	75 21	08.33 S
Orion's right Shoulder	1	♊ 24.55	16.05 S	85.05	7.19 N
Great Dog Syrius	1	♋ 10,19	39.32 S	98 17	16.21 S
Little Dog, Procyon	1	♋ 22.00	15.58 S	111.14	05.54 N
Hydra's Heart, Alphard ———	1	♌ 23.28	22.21 S	138.31	7.29 S
Lyon's Heart Regulus	1	♌ 26.01	00.37 N	148.26	13.17 N
Foot of the Croſiers	2	♍ 08.08	52 45 S	183.05	61.31 S
Virgin's Spike ———	1	♎ 20.01	02.02 S	197.44	09.43 S
Arcturus in Bootes	1	♎ 20.24	30.57 N	210.48	20.39 N
*Bright * of the Harp Lyra* — -	1	♑ 14.27	61.46 N	276.54	38.33 N
South Fiſh, Fomelhaut —— ———	1	♒ 29.59	21.05 S	340.35	31.03 S

Problem 22. *To find the Riſing, Setting, and Culminating of a Star at any Time, in any Latitude.*

The Rule 1. Rectifie the *Globe* and *Hour-Index*, as in *Prob* 10.

2. Bring the Star, (whoſe Riſing you would know) to the Eaſt Part of the Horizon, and then the Index will point to the Time of its Riſing: Alſo the Degree of the Horizon againſt the Star, is its Amplitude at Riſing.

3. Bring the Star to the Braſs Meridian, and the Index will ſhew the time of its Culminating (or coming to the Meridian) Alſo the Degree on the Braſs Meridian, contained from the Horizon to the Star, is its Meridian Altitude.

4. Bring the Star to the Weſt part of the Horizon, and then the Index will ſhew the Time of its Setting: Alſo againſt the Star, on the Horizon, is its Amplitude at Setting, which is ever the ſame Quantity as at Riſing.

This is ſo eaſy to perform, and ſo often done in the *Problems* concerning the Sun, it needs no Example.

Problem 23. *To know at any time what Stars are above the Horizon, either riſing towards the Meridian, or falling from it, towards their Setting; alſo what's their Altitude and Azimuth.*

The Rule. 1. Rectifie the Globe, Hour-Index and Quadrant of Altitude, as before in *Problem* 10.

2. Turn the Globe 'till the Hour Index point to the given Time of the Day or Night; and there ſtay the Globe.

3. Then obſerve what Stars are even with the Eaſt part of the Horizon, thoſe are then Riſing; and all thoſe that are between the Horizon and the Eaſt ſide of the Meridian, are riſen above the Horizon, and are riſing towards the Meridian.

4. All thoſe Stars near the Braſs Meridian, are then near the Meridian of that Place; and thoſe at the Braſs Meridian are then on the Meridian of that Place.

5. If the Quadrant of Altitude be put to any Star, it will ſhew its Altitude at that Time and Place, and in the Horizon the Quadrant ſhews its Azimuth.

6. All thoſe Stars on the Weſt ſide of the Meridian are falling from it towards their Sitting; thoſe near the Horizon are Setting, and thoſe below the Horizon are Set.

In a Word, let the Globe (by help of a *Magnetical Needle*, or *Compaſs*, or otherwiſe) be ſet ſo, as the North Point of its Horizon may point to the true North in the Heavens, and the South Point to the South; then imagine your eye plac'd within the Globe at its Center, and that the Globe were tranſparent, or ſuppoſing a ſmall round hole thro' the Center of any Star, now your Sight paſſing through it, will direct to the Star in the *Heavens* correſpondant to that on the out ſide of the Globe.

This being Mathematically well conſider'd, will make the *Uſe of the Globes* eaſy, and very much conduce to the Knowledge of the Stars, a Thing not a little neceſſary in *Navigation*, but too much neglected by moſt *Mariners*.

Problem 24. *To find the Hour of the Night by the Altitude of a known Star.*

The Rule 1. Rectifie the Globe, Hour Index, and Quadrant of Altitude, as before in *Problem* 10.

2. Turn the Globe and Quadrant of Altitude till you bring the Star againſt its given Altitude in the Quadrant, and there ſtay them.

3. Then will the Index ſhew the Hour required; and the Quadrant will cut the Horizon in the Star's Azimuth.

Note, If the Star you obſerve be on the Eaſt-ſide of the Meridian, then turn the Quadrant of Altitude on the Eaſt ſide of the Braſs Meridian of the Globe: And if on the Weſt-ſide, turn the Quadrant alſo on the Weſt-ſide.

Example. *At* London, December *the* 12*th the Altitude of* Regulus, *or the* Lion's Heart, *being* 25*d.* 30*m. Oriental, or on the Eaſt ſide of the Meridian: I demand the Hour of the Night?*

Anſw. According to the aforeſaid Rule, the Hour is near 30m. after 10 at Night, and the Star's Azimuth 78d. 30m. South Eaſterly, or Eaſt by South neareſt.

So much for the Uſe of the *Globes*, which is gone far beyond it's firſt deſigned Limit, occaſioned by a conſtant Reſolution to be plain.

And by the Way, let me adviſe thoſe who have not Conveniency for, nor Ability to purchaſe *Globes*; and yet would know the Stars, they may attain it with a pair of Hemiſpheres, wherein are all the Conſtellations; and each Star according to its Longitude and Latitude placed in them: ſuch are made of near 20 Inches Diameter, to fold in a Book, like a Sea-Chart, in 4 leaves; they are projected on the *Plain of the Ecliptic*, or as ſome ſay, on the *Poles of the Ecliptic*: So that in one Hemiſphere (which is one Leaf) you have all the Conſtellations on the North-ſide of the Ecliptic, and in another all the Southern.

The *Poles of the Ecliptic* is the Center of each Hemiſphere, and the Margent going round them is the Ecliptic, being divided into the 12 Signs, and each Sign into 30 Degrees, each Degree being ſubdivided into Halves and Quarters: And Lines drawn from the Center (or *Pole of the Ecliptic*) to the beginning of each Sign.

On one of thoſe Lines is placed the Degrees of Latitude, and numbred from the Ecliptic with 10, 20, *&c.* to 90, at the Pole and Center of it.

By theſe Hemiſpheres any of the former *Problems* (wrought on the *Cœleſtial Globe*) may be ſolved: As for Inſtance;

To find the Longitude and Latitude of a Star.

The Rule 1. Stretch out the Silk-String (faſtned in the *Center* for that purpoſe) over the *Center* of the given Star, and it ſheweth or cutteth the Star's Longitude in the *Ecliptic.*

2. With a Pair of Compaſſes take the Diſtance from the Center of the Star to the Center of the Hemiſphere; lay that Diſtance on the Scale of Latitude from the Center of the Hemiſphere, and it will ſhew the Latitude required.

Example *The Foot of the* Croſiers, *a Star of the ſecond Magnitude, in the Southern Hemiſphere, between* Robur Carolinum, *and* Centaurus: *I demand its Latitude and Longitude?*

1. Laying the like Silk String over the Star's Center, it cuts the Ecliptic in ♏ 8d. the Star's Longitude.

2. Take the Star's Diſtance from the Center of the Hemiſphere, meaſure it on the Solſtitial Colure, from the ſaid Center, and it reacheth to 53d, 10m. the Star's Latitude South.

There are drawn in theſe Hemiſpheres the Equinoctial, Tropics, Polar Circles, and Poles of the World; all which are deſcribed by their Names ſet to them: More Circles may be drawn, and are of Uſe in ſolving other *Problems*; which ſhall be ſhewed after the *Problems* of *Aſtronomy*.

CHAPTER VII. *Spheric Trigonometry, applied in* Problems *of* Geography.

BEfore I treat of *Great Circle-Sailing*, it's not amiſs to diſcourſe ſomething in *Geography*; and for a more diſtinct Knowledge thereof, take theſe following Definitions and Problems. Theſe Definitions are much the ſame as before, in *Chapter* 4. of *Mercator's-Sailing, in Page* 82.

Section I. *Geographic Definitions. Plate* 5. *Figure* 1.

1. THE *Earth* (on which we dwell) together with the *Water*, makes one round Body or Globe, which is the Subject of *Geography*.

2. The *Poles of the Earth*, are two imaginary Points, directly oppoſite, upon the Surface of it; that in the North, called the North Pole; and that in the South called the South Pole; As P and I. *Plate* 5. *Figure* 1.

3. The *Equator*, or Line under the *Equinoctial*, is a Line drawn round the Globe, and lieth in the middle between both Poles cutting all Meridians at Right Angles; is a Great Circle from which Latitude taketh it's beginning, and in which Longitude is reckon'd, as ÆAQ. *Plate* 5. *Figure* 1.

4. *Meridians* are great Circles drawn thro' both *Poles*, cutting the Equator at Right Angles, as PQI, PAI and PMI; anſwerable to them, are the *North* and *South Lines* drawn in any Chart.

5. *Parallels of Latitude*, are leſſer Circles drawn Parallel to the Equator; thro' every Degree and Minute of the Meridian between the Equator and each Pole as *a l t* and Z ✳ *l t*, and are repreſented in any Chart, by the Eaſt, and Weſt Lines therein.

6. *Latitude*, is an Arch of a Meridian, contained between any Parallel, and the Equator, from whence it is counted both ways to each Pole, where it ends in 90 Degrees, which is the greateſt Latitude.

7. *North Latitude*, is on that Side of the *Equator* towards the *North Pole*, and *South Latitude*, towards the *South Pole*.

8. *Difference of Latitude*, is an Arch of a Meridian, and the neareſt Diſtance between any two Parallels, and ſheweth how far any Place is to the Northward or Southward of another Place, and never exceedeth 180 Degrees.

9. *Longitude*, is reckon'd in the Equator, round which, increaſing to the Eaſtward it's counted (by ſome) till it end (where it firſt began) in 360 Degrees, which is the greateſt Longitude: Or, according to Mr. *Wakely* in his *Mariners Compaſs Rectified*, it's counted from the Meridian of *London*, increaſing on both ſides of it, Eaſtward and Weſtward, till it terminates in 180 Degrees, at the oppoſite Meridian.

10. *Longitude of a Place*, is an Arch of the *Equator* contain'd between the Meridian of that Place, and the Firſt Meridian where Longitude taketh its beginning, and counted (by the old Way) to the Eaſtward of the Firſt Meridian, but (by the new Way) it's counted both Eaſtward and Weſtward, from the Meridian of *London*: which in this Account is the Meridian, whence Longitude taketh its Beginning.

11. *Difference of Longitude*, is an Arch of the Equator, contained between the Meridians of any Two Places, and never exceedeth 180 Degrees.

12. *The Diſtance of any two Places*, is an Arch of a *Great Circle*, paſſing thro' them; and never exceedeth 180 *Degrees*

13. *The Angle of Poſition*, or the Angle of Scituation of Places, is an Angle the Arch of a Great Circle paſſing over two Places, makes with the Meridian of one of them, and is not the Courſe leading from one to the other

In finding the *Diſtance of Places*, there are 3 *Caſes*: As (1.) when they differ only in *Latitude*; (2.) when they differ only in *Longitude*; and (3.) when the two Places differ both in *Latitude* and *Longitude*; all which are performed by the following *Problems*.

Section

Section II *Geographic Problems.*

Caſe 1. *Two Places differing only in* Latitude *given; to find their Diſtance.*

Note 1, TWO *Places* under one Meridian, or bearing North and South from each other, or in one Longitude, are ſaid to differ only in Latitude.

2. Two Places differing only in Latitude, the Difference of Latitude is the Diſtance required: In which there are two Varieties.

Variety 1. Problem 1. *Two Places both on the ſame ſide of the Equator, that is, both in North, or both in South Latitude; to find their Diſtance.*

The Rule. Subtract the leſſer Latitude from the greater, the Remainder (reduce into Leagues or Miles) is the Diſtance required:

Variety 2. Problem 2. *If one Place be on one ſide of the Equator, the other on the other ſide; that is, one in North Latitude, and the other in South Latitude; to find their Diſtance.*

The Rule. Add the two given Latitudes together, the Sum (reduce into Leagues or Miles) is the Diſtance required.

Theſe are ſo eaſy, it's needleſs to give Examples, being the ſame you had in *Chapter* 3. *Section* 3. *General Rule* 2. in *Plain Sailing, in page* 58.

Caſe 2, *Two Places differing only in Longitude given; to find their Diſtance.*

Note; Two Places differing only in Longitude lie Eaſt and Weſt from each other, and are either in the Equator or elſe in one Parallel of Latitude.

In this Caſe are two Varieties.

Caſe 2. Variety 1. Problem 3 *Two Places in the Equator, their Longitudes being given; to find their Diſtance.*

The Rule. 1: According to the old Way of counting the Longitude, ſubtract the leſſer Longitude from the greater, the Remainder (if leſs than 180 Degrees) is the Diſtance requir'd; But when 'tis more, ſubtract it from 360 Degrees and this laſt Remainder is the Diſtance.

2. According to the New Way of counting the *Longitude* in the *Mariners Compaſs Rectified*, the Rule is thus;

If both Long. be Eaſt, or both Weſt, ſubtract the leſſer from the greater, the Remainder is their *Diſtance*: But when one is in Eaſt and the other in Weſt Long. add them, and the Sum (if it exceed not 180d.) is the Diſt. and when it doth exceed

180 Degrees ſubtract it from 360 Degrees, the Remainder is the Diſtance required, which is the ſame as in *Chapter* 4. *Section* 2. *Problem* 3. *Page* 89 of *Mercator's Sailing.*

Caſe 2. Variety 2. Problem 4. *Two Places in one Parallel, or both in one Latitude, their Longitudes being given to find their Diſtance.*

Example. *I demand the diſtance between the* Lizard *and* Pengwin Iſland *in* Newfoundland ?

		d m.		d m
Lizard *Pengwin Iſland*	Latitude	50 00 N.	Longit.	5 24 W 53 10 W
Subtract from		90 00	Diff. Lon.	47 46
Rem. is Comp. Lat.		40 00		

Theſe Places ſuppoſed both in the Latitude of 50d. 00m. North, whoſe Complement is 40d. 00m.

To delineate this Problem *Sterographically* on the *Plain* of the Meridian of the *Lizard. Plate* 5. *Figure* 1.

1 Deſcribe the Circle Æ P Q I, with a Chord of 60 deg. or Half-Tangent of 90 Degrees, and Quarter it, with the two Diameters or Right Circles PAI, and ÆAQ: Then is P the North Pole, I the South Pole, and ÆAQ the Equator.

2. By *Problem* 2. *Caſe* 2. *Page* 112 *of Spheric Geometry* make the Angle ÆPN equal to 47d. 46m. (the Difference of *Longitude*) by drawing the Oblique Circle P⊙NI, with the Secant thereof.

3. Make PZ equal to 40d. 00m. (the Complement of the iven Latitude) by *Prob.* 6. *Caſe* 1. *Page* 116 *of Spheric Geometry.*

4. Through Z draw the Parallel Circle Z ⊙ I t (by *Problem* 9. *Caſe* 2. *in Page* 121 of *Spheric Geometry*,) with the Tangent of 40d. 00m. (the Complement of the given Latitude) to cut the Oblique Circle P⊙NI in ⊙: Then Z repreſents the *Lizard*, and ⊙ *Pengwin Iſland*, both in one Parallel of Latitude.

5. Then through Z and ⊙, draw a great Circle, as is the Oblique Circle Z⊙C, and its done; for Z⊙ on the Oblique Circle is the Diſtance required, which is meaſured by *Problem* 7. *Caſe* 3. in *Page* 118 *of Spheric Geometry.*

To find their Diſtance by *Trigonometry*, 'tis to be noted;

That in the Oblique Spheric Triangle ZP⊙. *Plate* 5. *Fig* 1.

1 The Side ZP equal to P⊙ is the *Comp. of the Lat.* 40d. 00m.

2. The Angle ZP⊙ the *Difference of Longitude.*—— 47d. 46m.

3. The Side Z⊙ the Diſtance of the two Places; which to find, let fall the Perpendicular PB (by drawing an Oblique Circle with the Secant of 23d. 53m. half the (given) Difference of Longitude to cut the Oblique Circle Z ⊙ in B) and it divides the Oblique Spheric Triangle into two equal Rectangle Spheric Triangles PBZ and PB⊙, in each the Hypotenuſe, and one Angle is given.

1. The Angle Z P B equal to B P ⊙, is half the Difference Longitude, 23d. 53m.

2. The Leg ZB equal to B⊙, is half the Diſtance required.

Therefore the Proportion by *Chapter* 5. *Section* 4. *Problem* 2. *Caſe* 4. *in page* 136. of *Rectangular Spheric Trigonometry*, is thus;

As Radius, is to the Sine Complement of the Latitude; ſo is the Sine of half the Difference of Longitude, to the Sine of half their Diſtance required. But in ſhort thus,

As Radius .. S.*Hypot.* PZ : : S *Angle* ZPB .. S.*Leg* ZB $\frac{1}{2}$ the Diſt.
As S. 90d .. S 40d. 00m. : : S 23d. 53m .. 15d. 05m.

Which being doubled makes the Diſtance 30d. 10m. or 1810 Minutes, which is the Diſtance between the *Lizard* and *Pengwin* Iſland, in the Arch of a Great Circle.

Problem 5. *To find how many Miles or Minutes of the Equator make a Degree of Longitude in any Parallel of Latitude.*

The Rule, or Proportion is;

As Radius, is to 60 Miles or Minutes a Degree of the Equator.

So is the Sine Complement of the Latitude, to the Miles or Minutes of the Equator, which makes a Degree of Longitude in the Parallel required.

Example. *How many Miles will make a Degree in the Latitude of* London.

As Radius .. S.c.Lat. :: a deg. in the Equa. .. a deg. in the Par.
As S. 90d. .. S. 38d. 28m :: 60 Minutes .. Min. 37. 32 Parts

The Miles of the Equator that make a Degree of Longitude in the Latitude of 51d 32m.

Caſe 3. *Two Places differing both in Latitude and Longitude, their Latitudes and Longitudes being given; to find their Diſtance.*

Note, In this Caſe are three Varieties.

Variety 1. Problem 6. *One Place in the Equator, and the other towards either of the Poles.*

Example. *Suppoſe the* Lizard *and the Entrance of the River* Amazones, *their Latitudes and Longitudes being as followeth: I demand their Diſtance?*

		d m.		d m.
Lizard	Lat.	50.00	Longit.	5.24 W.
Amaz. River		00.00		48.04 W.
Difference of Longitude				42.40

To Delineate it *Stereographically* on the Plain of the Meridian of the *Lizard*, *Plate* 5. *Figure* 1.

1. The Circle being deſcribed, and quarterd as before, in *Problem* 4. make ÆZ on the Primitive Circle equal to 50d 00m: the Latitude of the *Lizard*, by *Problem* 6. *Caſe* 1. *in page* 116 of *Spheric Geometry*.

2. By the ſame *Problem*, *Caſe* 2, lay 42d. 40m. the given Difference of Longitude, on the Right Circle ÆAQ (which is the Equator) that is, take the Half-Tangent 42d 40m. the contrary Way, and lay it from ÆN.

3. Then through Z and N draw a Great Circle, as is the Oblique Circle ZNC, and it's done: For ZN (meaſured by *Problem* 7. *Caſe* 3. in *page* 118. of *Spheric Geometry*) is the Diſtance required.

But to find their Diſtance by Trigonometry. Obſerve,

That in the Rectangle Spheric Triangle ZÆN. *Plate* 5. *Figure* 1.

1. The Leg ZÆ is the Latitude of the *Lizard*, 50d. 00m.

2. The Leg ÆN the Difference of Longitude between them 42d. 40m.

3. The Hypotenuſe ZN their Diſtance required: to find which (by *Chapter* 5. *Section* 4. *Problem* 5. *Caſe* 14. in *page* 140. of *Rectangular Spheric Trigonometry*) the Proportion is thus:

As Radius is to the Sine Complement of the *Lizard* Latit.

So is the Sine Complement of their Difference of Longitude; to the Sine Complement of their Diſtance required. But in ſhort thus.

Radius .. S.c LegZÆ : : S.c Leg ÆN .. S.c. *Hypot.*ZN the *Diſt.*
S.90d .. S 40d.00m, : : S. 47d 20m. .. S. 28d. 12m. whoſe Complement is 61d 48m. equal to 3708 Minutes is the Diſtance between the *Lizard* and River *Amazones*.

Caſe 3. Variety 2. Problem 7. *Two Places lying towards one of the Poles; that is both in* North *Latitude, or both in South Latitude, their Latitudes and Longitudes being given: to find their Diſtance.*

Example *I demand the Diſtance between the* Lizard *and Iſland* Barbadoes.

Lizard,

		d m.		d m.
Lizard	Lat.	50 00	Longit.	5 24 W.
I. Barbadoes		13.00		57 54 W.
Difference of Longitude				52 30

To Delineate this *Stereographically*, on the Plain of the Meridian of the *Lizard.*

1. Having deſcribed the Primitive Circle, and quarter'd it as before. make the Angle ÆPM by *Problem* 2. *Caſe* 2. in *page* 112. of *Spheric Geometey*, equal to 52d 30m. the given Difference of Longitude, by drawing the Oblique Circle PMI with the Secant thereof.

2. On the Primitive Circle (by *Prob.* 6, *Caſe* 1. in *page* 116. of *Spheric Geometry*) make PZ equal to 40d. 00m. the Complement of the *Lizard* Latitude, by having the Chord thereof from P to Z.

3. Draw the Parallel Circle a L l t (by *Problem* 9, *Caſe* 2. in Page 121 of *Spheric Geometry)* at 13d. 00m. (*Barbadoes* Latitude) Diſtance from the Right Circle ÆAQ. the Equator, to cut the Oblique Circle PMI in L.

4. Then thro' Z and L draw a Great Circle, as the Oblique Circle ZLNC, and its done: for ZL (meaſured by *Problem* 7. *Caſe* 3. *in page* 113 of *Spheric Geometry*) is the Diſtance required.

But by Spheric Trigonometry, to find their Diſtance, it is to be noted.

That in the *Oblique Spheric Triangle*, ZPL. *Plate* 5. *Figure* 1.

1. The ſide PZ is the Comp. of the *Lizard* Lat. 40d. 00m.
2. The Side PL the Comp. of *Barbadoes* Lat. 77d. 00m.
3. The Angle ZPL their Difference of Longit. 52d. 30m.
4. The Side ZL their Diſtance required

To (find which, by *Chapter* 5. *Section* 5. *Problem* 9. *Caſe* 8. *in page* 145. of *Spheric Trigonometry Oblique*) The Rule is,

Firſt, As Radius is to the Sine Complement of the Difference of Longitude; So is the Tangent Complement of the greater Latitude, To the Tangent of a Fourth Arch.

Which being ſubtracted from the Complement of the leſſer Latitude, when the Difference of Longitude is leſs than 90 Degrees, but when more than 90 Degrees from its Supplement to 180 Degrees, the Remainder is the *Reſidual Arch.* Then.

Secondly, As the Sine Complement of the *Fourth Arch* aforefound, is to the Sine Complement of the *Reſidual Arch*; So is the Sine of the greater Latitude, to the Sine Complement of

the Diſtance required. But in ſhort, as follows;
AsRadius .. S.c.Angle ZPL. : : T. Side ZP .. T. 4th Arch,
AsS.90d. .. S. 37d. 30m : : T.40d.00m. .. T.27d. 04m. which being ſubtracted from the Side PL 77d 00m. the
Remainder is the Reſidual Arch ———— 49d. 56m.

Then again, ſay,
As S.c. 4th *Arch* .. S.c.*Reſid Arch* : : S.c. *Side* ZP .. Sc. *Side* ZL
As S 62d. 56m. .. S. 40d. 04m, : : S.50d. 00m .. S. 33d. 37m.

Whoſe Complement 56d. 23m. or 3383 Minutes, which is the Diſtance from the *Lizard* to Iſland *Barbadoes* in the Arch of a Great Circle.

Caſe 3. Variety 3. Problem 8. *Two Places, one in North Latitude, the other in South Latitude; their Latitudes and Longitudes given, to find their Diſtance.*

Example. *I demand the Diſtance from* Cape Cod *in* New-England, *to Cape* Bona Eſperance *or Cape of* Good Hope *in* Africa.

	Lat. d m.	Longit. d m.
Cape Cod	42 10 N.	67 45 W
C. Bon. Eſp.	34 25 S.	17 10 E

Difference of Longitude is ———— 84 55

To delineate it *Sterographically* on the Plain of the Meridian of Cape *Cod. Plate* 5, *Figure* 1.

1. The Primitive Circle being deſcribed, and quarter'd as before directed, make (by *Problem* 2. *Caſe* 2. *in page* 112. of *Spheric Geometry*) the Angle ÆPM equal to 84d. 55m. the given Difference of Longitude, by drawing the Oblique Circle PMI with the Secant thereof: But the Secant is ſo large, that it's not eaſy to do, therefore in ſuch Caſes, lay it on the Right Circle ÆMAQ, the Equator (by *Problem* 6. *Caſe* 2. in Page 116 of *Spheric Geometry*) from Æ, to M that is from the Scale of Half Tangents the contrary way; and laying a Bow ſcrew'd up to the three points PM, and I, draw the Oblique Circle by it.

2. On the Primitive Circle, (by *Problem* 6. *Caſe* 1. in Page 116.) make PZ equal to 47d. 50m. the Complement of *Cape Cod's* Latitude.

3. Draw the Parallel Circle *a D l t* (by *Problem* 9. *Caſe* 2. *in page* 121) at 34d. 25m. Cape *Bon Eſperance* Lat. (or diſtance from the Right Circle ÆAQ the Equator) to cut the Oblique Circle PMI, in D, repreſenting Cape *Bon-Eſperance.*

4. Through Z and D; draw a Great Circle, as the Oblique *Circle* ZDC, and it's done: For ZD meaſured by *Problem* 7. *Caſe* 3. in Page 118 of *Spheric Geometry*) is the Diſtance requir'd.

By *Spheric Trigonometry*, to find their Diſt. it's to be conſider'd, That in the Oblique Spheric Triangle ZPD. *Plate* 5. *Fig.* 1.

1. The Side PZ is the Comp. of *Cape Cod*'s Latit. 47d. 50m.

2. The Side PD the diſtance of *Cape Bon Eſperance* from the North Pole, or its Latitude added to 90d. that is 124d. 25m.

3 The Angle DPZ their Differ. of Longitude 84d. 55m.

4. The Side ZD their Diſt. required, which is thus found.

By *Chapter* 5. *Section* 5. *Problem* 9. *Caſe* 8, *in page* 145, *of Spheric Trigonometry Oblique*, the Proportions are theſe.

Firſt, As Radius, is to the Sine Complement of their Difference of Longitude; ſo is Tangent Complement of one of the given Latitudes, to the Tangent of a Fourth Arch. Then,

If the Difference of Longitude be leſs than 90d. ſubtract the Fourth Arch out of the other Latitude, added to 90d. but if the Diff. Long. be more than 90d. from the Supplement thereof to 180d. the Remainder is the Reſidual Arch, And then,

Secondly; As the Sine Complement of the Fourth Arch, is to the Sine Complement of the Reſidual Arch; So is the Sine of the Latitude firſt taken, to the Sine Complement of the Diſtance required. But in ſhort thus;

As Radius .. S.c.Ang DPZ : : T. Side PZ .. T. 4th Arch.
As S. 90d. .. S. 05d. 05m. : : T. 47d. 50m. .. T. 5d. 35m. which
being ſubtracted from the Side PD ——— 124d. 25m.

The Remainder is the Reſidual Arch ——— 118d. 50m.
Then again ſay,

S.c.4th *Arch* .. S.c. *Reſidual-Arch* : : S.c. *Side* PZ .. S.c. *Side* ZD
S. 84d. 35m. .. S. 28d. 05m. : : S. 42d. 10m. .. S. 18d. 59m.
Which added to ——— 90d. 00m.

The Sum is the Side ZD their Diſtance ——— 108d. 59m.

Or 6599 Minutes is the Diſtance from Cape *Cod* to Cape *Bona Eſperance*, in the Arch of a Great Circle.

CHAPTER VIII.

Of the Third Part of Navigation, or the Doctrine of Spheric Trigonometry, applied in Great Circle-Sailing.

G*reat Circle Sailing*, as it's the exacteſt, ſo it's the moſt difficult, and hardly poſſible for a Ship exactly to Sail by; yet it may be of good Advantage to keep conveniently near it, eſpecially in a Parallel (or Eaſt and Weſt) Courſe.

2. *Great Circle-Sailing*, is Sailing by, or upon the Arch of a Great Circle, paſſing thro' the Two Places.

3. In *Great Circle-Sailing*, are but Three Caſes, *viz.* (1.) When two Places differ only in Latitude; (2) When they differ only in Longitude; and (3.) When they differ both in Latitude and Longitude.

Caſe 1. *Two Places differing only in Latitude, their Latitudes given; to find their Diſtance.*

1. This is the ſame with *Chapter* 7. *Section* 2. *Problem* 1. and 2. in *page* 183 of *Geography*, to which I refer the Reader for finding their Diſtance, and ſo paſs to

Caſe 2. *Two Places differing only in Longitude, the Latitude and Longitude being given; to find their Diſtance in the Arch of a Great Circle, and all that's requiſite in* Great Circle-Sailing.

1. This is the ſame with *Chapter* 7, *Section* 2. *Problem* 3. *and* 4. in *pages* 183 *and* 184. of *Geography*, to find their Diſtance.

2. Theſe Places are either in the Equator, or in one Parallel, and lie Eaſt and Weſt from each other; but their Diſtance in that Parallel, is not their neareſt Diſtance, the Parallel being a Leſſer Circle.

3. The Diſtance in the Parallel hath been ſhewed in *Chapter* 4. *Section* 3. *Problem* 10 *of Mercator*'s-*Sailing*, *in page* 100, and their Diſtance in the Arch of a Great Circle is found by *Chapter* 7. *Section* 2. *Problem* 4. *in page* 184, *of Geography*. But the Angles of Poſition made by the Great Circle, and it's Latitude, and Longitude at any aſſign'd Portion, together with the Courſe, and Diſtance from Place to Place, ſo aſſign'd in it, is the Work now.

Caſe 2. Prob. 1. *Suppoſe the* Lizard, *and* Pengwin-Iſland, *both in the Latitude of* 50d. 00m. *North, whoſe Difference of Longitude is* 47d. 46m. (*as before in* Prob. 4 in Page 184 of Geography:) *I demand the Angles of Poſition? The Great-Circle's Diſtance between them? The Latitude of the Arch at every five Degrees Difference of Longitude? And the Courſe, and Diſtance of each of them according to* Mercator.

This Problem is delineated by the Directions in *Problem* 4. of *Geography*, in *page* 184. And obſerve that,

In the Oblique Spheric Triangle APC. *Plate* 5. *Fig* 2.

1. A repreſents the *Lizard*.
2. C *Pengwin Iſland*.
3. The ſide PA equal to PC, the Complement of their Latitude 40d.
4. The Angle APC the Difference of Longitude 47d. 46m.
5. The Angle CAP equal to ACP, the Angle of Poſition at each Place.
6. The Side AC, the Great Circle's Diſtance between them.

Firſt, For the Angle CAP equal to ACP, the Angle of Poſition at the Two Places.

Draw the Perpendicular P B, (as was taught in *Problem* 4. of *Geograpy*, in *page* 185.) which divideth the Oblique Triangle APC into two equal Rectangle Spheric Triangles ABP and CBP; in each the Hypotenuſe, and one Angle is given That is,

1. The Hypotenuſe PA, equal to PC, the Complement of their Latitude 40 Degrees.
2. The Angle BPA, equal to BPC, half their Difference of Longitude 23d. 53m.
3. The Angle BAP, equal to BCP, the Angle of Poſition, at each Place.
4. The Leg AB, equal to BC, half the *Great Circle's* Diſtance.
5. The Leg BP the Complement of the Arch's greateſt Lat.

And by *Chapter* 5. *Section* 4. *Problem* 2. *Caſe* 6. *of Spheric Trigonometry Rectangular, in page* 137. the Proportion is thus;

As Radius, is to the Sine of the Latitude; ſo is the Tangent of half the Difference of Longitude, to the Tangent Complement of the Angle of Poſition at each Place. That is;

As *Radius* :· S.c. *Hypot*. AP : : T. Angle APB ·· T c. Angle BAP.
As S. 90d. ·· S. 50d. 00m. : : T. 23d. 53m. ·· T. 18d. 44m.
Which being ſubtracted from ——— 90d. 00m.
Remain. is the Angle of Poſition at each place 71d 16m.

Secondly, The Leg AB equal to BC is found (by *Problem* 4. of *Geography*, in *page* 185) 15d. 05m. and therefore the Side AC is 30d. 10m or 1810 Minutes, the Diſtance of the two Places in the Arch of a Great Circle,

Thirdly, To find the Latitude by which the Arch ſhall paſs at every 5 Degrees Difference of Longitude from A repreſenting the *Lizard*; theſe Things following muſt be obſerved.

Firſt, Find the Leg BP, the Complement of the greateſt

Latitude by which the Arch (of the great Circle) doth paſs; and that by *Chapter* 5. *Section* 4. *Problem* 2. *Caſe* 5. *of Spheric Trigonometry Rectangular*, in *Page* 137) is thus;

As Radius, is to the Sine Complement of half the Difference of Longitude.

So is the Tangent Complement of the given Laritude, to the Tangent Complement of the Arch's greateſt Latitude; In ſhort thus;

As Radius ·· S.c.Angle BPA : : T, Hypot. PA : :T.c.Leg BP
As S 90d. ·· S. 66d. 07m. : : T. 40d.00m. ·· T. 37d. 30m.
Which being ſubtracted from ———— 90d. 00m.
Remainder is the Arch's greateſt Latitude ——— 52d. 30m.

Secondly, To find the Latitude by which the Arch of the Great Circle paſſes at every 5 Degrees of Longitude from A, draw Meridians from P, as Pd, Pe, Pf, &c. which may moſt eaſily be done *Gnomonically*, being then Right Lines, and that is thus;

The Gnomonic Projection. Plate 5. Figure 3.

1. Make the Angle APC equal to 47d. 46m. the Difference of Longitude between the two given Places.
2. Make PA, and PC, each equal to the Tangent of 40d. 00m. the Complement of the given Latitude.
3. Draw the Line AC, which repreſents the Arch of a great Circle between them.
4. Let fall the Perpendicular PB, which being meaſured on the Scale of Tangents, is 37d. 30m. the Complement of the Arch's greateſt Latitude.
5. Then draw Lines from P, each 5 Degrees diſtance from A, as Pd, Pe, Pf, Pg, Ph, Pi Pk, Pl, and Pm; which are Meridians, and each 5 degrees of Longitude from A, the *Lizard*.
6. Meaſure Pd, Pe, Pf, &c. on the Scale of Tangents, and it ſheweth the Complements of the Latitudes of the Arch, at the reſpective Places d, e, f, &c.

Theſe are found (by *Spheric Trigonometry*) after this manner: The ſeveral prick'd Lines Pd, Pe, &c. are ſo many Hypotenuſes, to as many Rectangular Spheric Triangles, which have one common Leg BP, the Complement of the Arch's greateſt Latitude.

Now in each of theſe Rectangular Spheric Triangles, there is given a Leg, and its adjacent Angle, to find the Hypotenuſe; that is, in the Triangle dBP, there is given the Leg BP, and Angle BPd; to find the Hypotenuſe Pd, and ſo in all the reſt.

And the ſeveral Angles B P d, B P e, *&c.* are found by a continual Subtraction of 5 Degrees from the Angle BPA 23d. 53m. half the Difference of Longitude, till the Remainder be leſs than 5 Degrees, which being taken out of 5 Degrees, and to this laſt Remainder add 5 Degrees ſucceſſively till the Sum exceed not 23d. 55m. That is;

		d. m
From the Angle	BPA	23.53
Subtract the Ang.	APd	5.00
Ramaind. is Ang.	BPd	18.53
	BPe	13.53
	BPf	08.53
	BPg	03.53
Which Subtract from		05 00
Is the Angle BPh		=01.07

		d. m.
Then to the Angle	BPh	01.07
Add the Angle	=hPi	05.00
Sum is the Angle	BPi	06.07
	BPk	11.07
	BPl	16.07
	BPm	21.07

These Angles are called *Vertical Angles*, or Angles at the *Pole*.

Then find (by *Chapter* 5. *Section* 4. *Problem* 3. *Caſe* 9. *of Spheric Trigonometry Rectangular*, in *pages* 137, and 138) the ſeveral Latitudes of the Arch, which is by this Proportion.

As Radius, is to the Sine Complement of the Vertical Angle;

So is the Tangent of the Arch's greateſt Latitude, to the Tangent of the Arch's Latitude at the reſpective places. Or,

As Radius .. S c. BPd, BPe, *&c.* : : T.c.Leg BP .. Tc Pd, Pe, *&c.*

As S. 90d. .. S. 71d.07m. : : T.52d.30m. .. T. 50d 48m *Lat* at d

76	07	51.41	Latitude at	e
81	07	52.10		f
86	07	52.26		g
88	53	52.30		h
83	53	52.29		i
78	53	51.59		k
73	53	51.23		l
68	53	50.34		m

So that by the *Gunter*, the Extent from the Sine of 90 degrees, to the Sine of 71d. 07m. will reach from the Tangent of 52d. 30m. to Tangent 50d. 58m. And the Extent from Sine 90d. to Sine 76d. 07m. will reach from Tangent 52d. 30m. to Tangent 51d. 41m. Alſo from Sine 90d to Sine 81d. 07m. reacheth from Tangent 52d. 30m. to Tangent 52d. 10m. and ſo on for the reſt.

But by Logarithms it may be thus contracted; becauſe the

Firſt and Third Terms in each Proportion are the ſame, and Radius being the Firſt, it follows,

That to the Tangent of the Arch's greateſt Latitude, add the Sine Complement of each Vertical Angle, and from their Sum abate Radius, the Remainder is the Tangent of the Arch's Latitude at each Place required. As for Example.

	d. m				d. m	
Arc greateſt Lat.	52.30	Tan.	10.115619			
	71.07	Sine	9.975974			
			10.090993	Tang.	50.58	d
	76.07	Sine	9.987124			
			10.102143	Tang.	51.41	e
	81.07	Sine	9.994759			
			10.109778	Tang.	52.10	f
	86.07	Sine	9.999002			
			10.114021	Tang.	52.26	g
	88.53	Sine	9.999917			
Comp. Vertital Angle			10.114936	Tang.	52.30	Latitude of the Place at h
	83.53	Sine	9.997520			
			10.112529	Tang.	52.21	i
	78.53	Sine	9.991774			
			10.106793	Tang.	51.59	k
	73.53	Sine	9.982587			
			10.097606	Tang.	51.23	l
	68.53	Sine	9.969811			
			10.084830	Tang.	50.34	m

Thirdly, To find the Courſe, and Diſtance of the aforeſaid Places, having now the Latgitude, and Longitude of them; this is done by *Chapter* 4. *Section* 3. *Problem* 2. *of Mercator's Sailing*, in *page* 93.

As for Example. To find the Courſe and Diſtance from A to d.

There is given the Latitude of A 50d. 00m. North, and of d 50d. 58m. North, with their Difference of Longitude 5d. or 300 Minutes Weſt.

Their Meridional Difference of Latitude (by the Table of Meridional Parts, in Pages 130, and 134) is 91 Minutes: Therefore,

For the Courſes, the Proportion is;

As Merid. Diff. Lat. ·· *Diff. Long.* :: *Radius* ·· T. *of the Courſe*
As 92d. Minutes ·· 300 Min :: T 45d. ·· T. 73d. 07m. N. Weſterly from A to d is the firſt Courſe.

For the Diſtances, the Proportion is,

As S.c. Courſe ·· Diff Lat. :: Radius ·· Diſtance
As S. 16d. 53m. ·· 58 Min. :: S. 90d. ·· 200 Min. from A to d.

After the ſame manner find the Courſes and Diſtances from d to e, from e to f, *&c*, as follows

For the Courſes, the Proportions are;

As 69 Min. ·· 300 Min. :: T. 45d. ·· T. 77.02 N W. from d to e.
47 ——— ——— ——— ——— 81.06 ——— from e to f.
26 ——— ——— ——— ——— 84.02 ——— from f to g.
6 ——— ——— ——— ——— 88.46 N W from g to h.
14 ——— ——— ——— ——— 87.15 S W. from h to i.
37 ——— ——— ——— ——— 83.08 ——— from i to k.
57 ——— ——— ——— ——— 79.14 ——— from k to l.
78 ——— ——— ——— ——— 75.26 ——— from l to m.
As 53 Min. ·· 166 Min. :: T. 45d. ·· T. 72d. 18m. S W from m to C

For the Diſtances, the Proportions are,

As S. 12d. 58m. ·· 43 Min. :: S. 90d. ·· 192 Min. from d to e.
8d. 54m. ·· 29 ——— ——— 187 ——— from e to f.
4d. 58m. ·· 16 ——— ——— 185 ——— from f to g.
1d. 14m. ·· 04 ——— ——— 186 ——— from g to h.
2d. 45m. 09 ——— ——— 187 ——— from h to i.
6d. 52m. ·· 22 ——— ——— 187 ——— from i to k.
10d. 46m. ·· 36 ——— ——— 190 ——— from k to l.
14d. 34m. ·· 49 ——— ——— 194 ——— from l to m.
17d. 42m. ·· 34 ——— ——— 111 ——— from m to C.

Which place orderly as in the Table following.

Places	*Plaees Latitudes.*	*Meridional Parts*	*Mer. iff Lat.*	*Difference of Longitude.*	*Diff. of Latitude*	*Courſes from Place to Place*	*Diſtances of Places*
	d m	Min.	Min	d. m	Min.	d m	Min.
A	50.00	3474					
d	50.58	3566	92	5 or 300	58	N 73.07 W	200
e	51.41	3635	69	5 or 300	43	N 77.02 W	192
f	52.10	3682	47	5 or 300	29	N 81.06 W	187
g	52.26	3708	26	5 or 300	16	N 85.02 W	185
h	52.30	3714	6	5 or 300	04	N 88.46 W	186
i	52.21	3700	14	5 or 300	09	S 87 15 W	1 8 7
k	51.59	3633	37	5 or 300	22	S 83.08 W	187
l	51.23	3606	57	5 or 300	36	S 79.14 W	190
m	50.34	3528	78	5 or 300	49	S 75.26 W	194
C	50.00	3475	53	2.46 or 166	34	S 72.1 W	111
			The whole Diſtance is ——				1819

But in Regard moſt of the Courſes in the Table are ſo near the Weſt, you may ſail WNW 927 Min. until you are in the Latitude of 56d. 00m. North; and then WSW. 927 Min. farther, you will arrive at the Port deſired.

By this means you alter the Latitude 6d. which is conſiderable, in reſpect of the Benefit of Obſervation; beſides the Diſtance (this way) is but 56 Minutes more than that of a Great Circle, aud not above 24 Minutes more than the Parallel or *Weſt* Diſtance; which is evident, if you compare *Chap.* 4. *Section* 3. *Problem* 10. of *Mercator Sailing*, in *Page* 101 with this

Caſe 3. *Two Places differing both in Latitude, and Longitude; their Latitudes, and Longitudes being given: to find their Diſtance in the Arch of a Great Circle, and all that is required in* Great-Circle Sailing.

Note; When two Places differ both in Latitude and Longitude, they lie neither in one Parallel nor under one Meridian; of which here are three kinds, *viz.* (1.) one Place under the Equator, and the other in North, or South Latitude. (2.) Both Places in North, or both in South Latitude: And (3.) One Place in North Latitude, and the other Place in South Latitude

Plate 5. Fig. II.

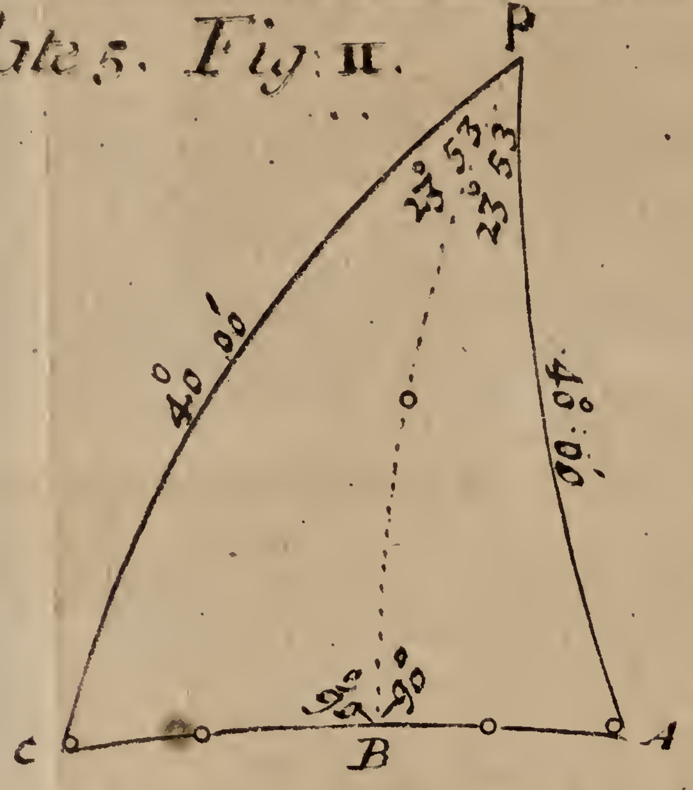


Plate 5. Fig. III.

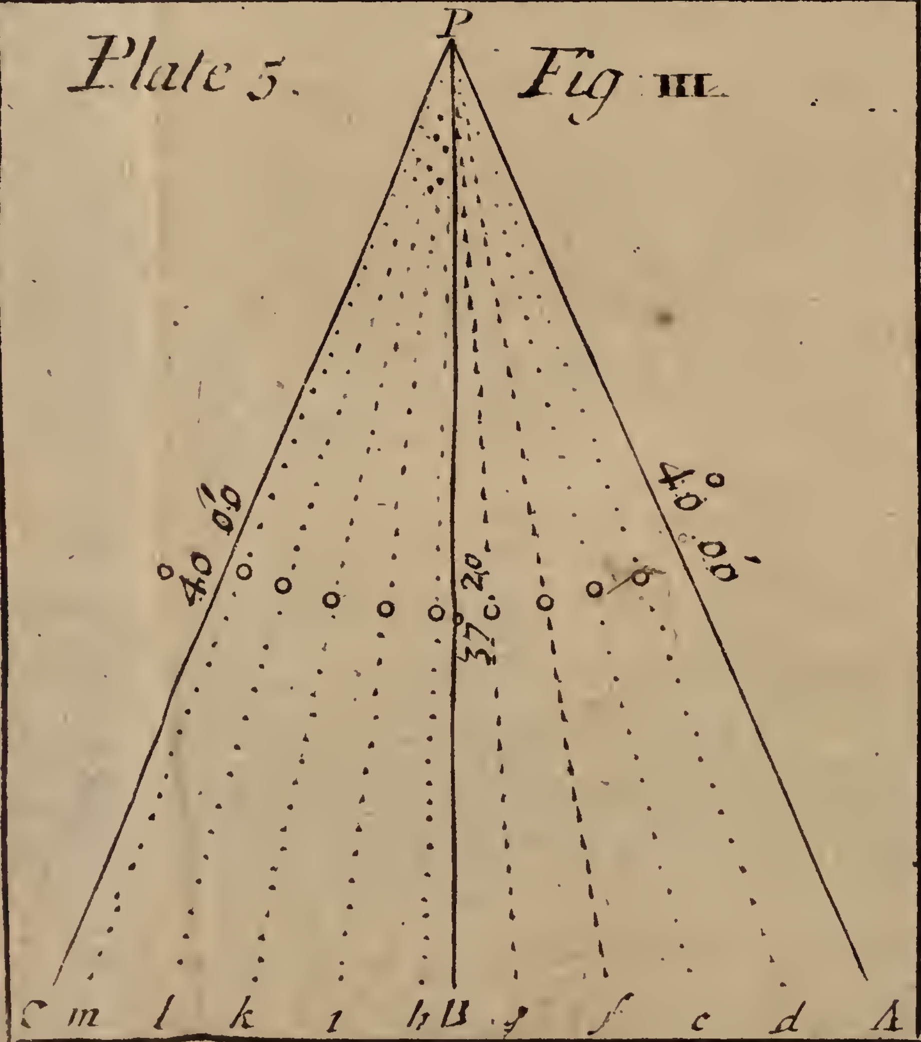
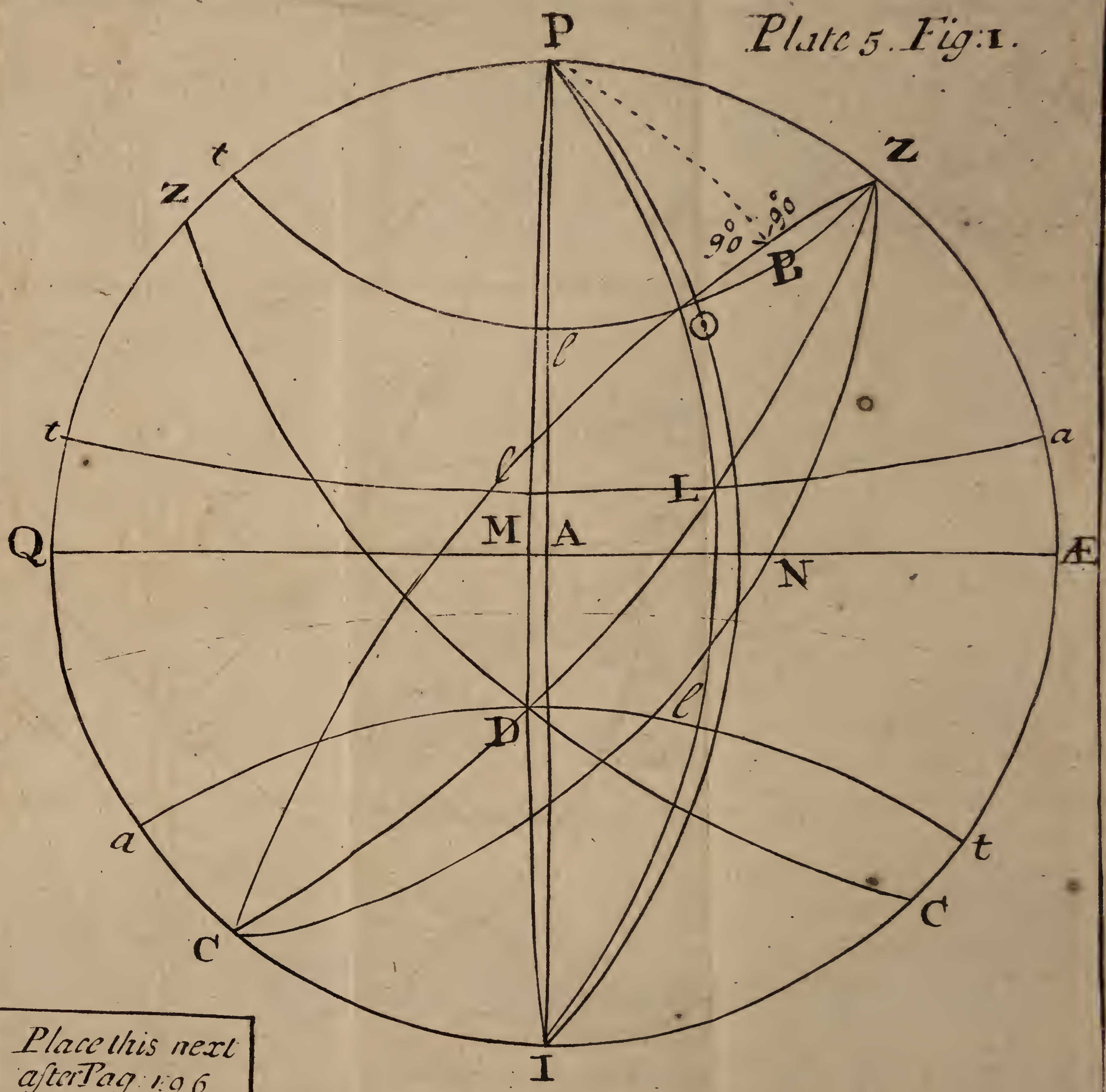


Plate 5. Fig. I.



Place this next after Pag. 196

Theſe three kinds of Places differing both in Latitude and Longitude; how to find their Diſtance in the Arch of a Great Circle, hath been ſhewed in *Chapter* 7. *Section* 2. *Caſe* 3. *Problems* 6, 7 and 8, of *Geography*, in *pages* 185, 186,[illegible]87 and 188. But to find the Angles of Poſition, and what elſe is requiſite in *Great Circle-Sailing*, is the Work of the three following *Problems*.

Caſe 3. The firſt Kind, *One Place under the Equator; the other in North, or South Latitude: As for* Example.

Problem 2. *Suppoſe the* Lizard *and the Entrance of the River* Amazones; *I demand the Angles of Poſition? the great Circle's Diſtance between them? The Latitude of the Arch at every* 10 *Degrees Difference of Longitude? with the Courſe, and Diſtance of each of them, acccording to* Mercator?

The Latitude, and Longitude of theſe Places, ſuppoſed to be as follows:

		d. m.		d m
Lizard ——	Latitude	50 00	Longitude	5.24 W
Amaz. River		00.00		48 04 W

And their Difference of Longitude ———— 42 40 W

This *Problem* is Delineated by the Directions in *Problem* 6. of *Geogragphy*, in *page* 186. And here Note; That,

In the *Rectangle Spheric Triangle* ZÆN. *Plate* 7. *Fig.* 1.

1. Z repreſents the *Lizard*.
2. N the Entrance of *Amazon* River.
3. ZÆ the Latitude of the *Lizard*, 50d. 00m.
4. The Leg ÆN their Difference of Longitude 42d. 40m.
5. ÆZN the Angle of Poſition at the *Lizard*.
6. ÆNZ the Complement of the Angle of Poſition at *Amazones*, in the Equator.
7. The Hypotenuſe ZN the Great Circle's Diſtance between them

For the Angles ÆNZ, or ÆZN (by *Chapter* 5. *Section* 4. *Problem* 5. *Caſes* 13 and 14. of *Spheric Trigonometry Rectangular*, in *pages* 139, and 140, the Proportions are theſe;

As Radius, is to the Sine of the Latitude; So is the Tangent Complement of the Difference of Longitude, to the Tangent Complement of the Angle of Poſition at the Place having Latitude: That is,

As Radius ·· S.Leg ÆZ : : T. c. Leg ÆN ·· T.c. Angle ÆZN.
As S. 90d. ·· S. 50d. 00m. : : T. 47d. 20m. ·· T. 39d. 44m.
Which ſubtract from ——— ——— ——— 90d. 00m.
Reſts the Angle of Poſition at the *Lizard* —— 50d. 16m.
And again,

As Radius, is to the Sine of the Difference of Longitude; So is the Tangent Complement of the *Lizard* Latitude, to the Tangent of the Angle of Poſition at the Place in the Equator; That is,

As Radius ·· S Leg ÆN : : T.c.Leg ÆZ ·· T c. Angle ÆNZ.
As S. 90d ·· S 42d. 40m. : : T. 40d. 00m. ·· T. 29d. 38m. the Angle of Poſition at *Amazones* which ſub. from 90d. 00m.
Angle ÆNZ ——— 50d. 22m.

For the Hypotenuſe ZN the Great Circle's Diſtance between them, that's found (by *Chapter* 7. *Section* 2. *Caſe* 3. *Problem* 6. of *Geography*, (in *page* 185, and 186) to be 61d. 48m. or 3708 Minutes.

To find the Latitude by which the Arch ſhall paſs, at every 10 Degrees Difference of Longitude, from Z repreſenting the *Lizard*, obſerve the following *Stereographic* Projection on the Plane of the Equator. *Plate* 6. *Figure* 1.

1. Deſcribe the Primitive Circle, on the Center P, which repreſents the Pole of the World, through it draw the Right Circle PZÆ, repreſenting the Meridian of the *Lizard*, and from the Half-Tangents lay 40d. the Complement of it's Latitude from P to Z

2. On the Primitive Circle lay 42d. 40m. the Difference of Longitude from Æ to N; alſo lay 10 deg from Æ to f, from f to g, and ſo on to i.

3. Thro' Z repreſenting the *Lizard*, and N the Entrance of *Amazones* River, draw a Great Circle, as ZN.

4 Draw the Right Circle's Pf, Pg, Ph, and Pi; which are Meridians and cut the Arch ZN in a, b, c, and d; the reſpective Places whoſe Latitudes are required.

5. Meaſure a f, b g, c h, and d i, on the Scale of Half-Tangents (the contrary way) and it ſheweth the Latitude of of the Arch at thoſe Places; and to find them,

By Spheric Trigonometry.

The ſeveral Right Circles a f, b g, *&c.* are ſo many Perpendiculars to as many ſeveral Rectangle Spheric Triangles, which have one common Angle ÆNZ, the Complement of the Angle of Poſition at that Place, which is in the Equator.

Now in each of theſe Rectangle Spheric Triangles, there is given a Leg, and it's adjacent Angle, to find the other Leg, which is the Leg oppoſite to the given Angle; that is, in the Triangle a f N, there is given the Leg f N, and Angle a N f; to find the Leg a f, and ſo in all the reſt of the Triangles.

And the ſeveral Legs N f, N g, &c. are found by a continual Subtraction of 10 Degrees from the Difference of Longitude, till the Remainder be leſs than 10 Degrees. The Remainders I call Vertical Arches, and is thus found.

d. m.
From the Leg ——— ÆN 42.40
Subtract the Arch — Æ f 10 00
Remaind. is the Leg N t 32.40
N g 22.40
N h 12.40
N i 2.40

Then (by *Chapter* 5, *Section* 4 *Problem* 3 *Caſe* 7. *of Spheric Trigonometry Rectangular, in pages* 137 and 138) to find the ſeveral Latitudes of the Arch, the Proportion is thus,

As Radius to the Sine of the Vertical Arch;
So is the Tangent Complement of the Angle of Poſition (at the Place in the Equator,) to the Tangent of the Arch's Latitude. Or thus;

As Radius ·· S. Nf, Ng, *&c.* : : T. Angle aNf ·· T. Leg af, bg, &c.
As S. 90d. ·· S. 32d.40m. : : T. 60d. 22m. ·· T. 43.30 Latit of a
22 40 ——— 34.07 b
12 40 ——— 21.05 c
2 40 ——— 4 41 d

I have calculated the Latitude of the Arch for every 10 Degrees Difference of Longitude, but by the ſame Method the Practitioner may do it for each 5 Degrees, and then it will be more exact.

The Courſe, and Diſtance from each of theſe Places are found (by *Chapter* 4. *Section* 3. *Problem* 2. of *Mercator's Sailing*, in *Pages* 93, and 94) in like manner as in the third Step of the laſt *Problem*, and is as followeth.

For the Courſes, the Proportion is.

As *Mer. Dif.* Lat. ·· *Dif. Long.* : : *Radius* ·· T. *of the Courſe* required
As 570Min. ·· 600Min : : T.45d. ·· T.46d. 55m SW. from Z to a
725 ——— 39d.37m. SW. from a to b
884 ——— 34d.10m. b to c
1014 ——— 30d.28m c to d
As 281Min. ·· 160Min. : : T.45d. ·· T.29d.39m. d to N

2. For the Diſtances, the Proportion is,

As S.c. Courſe .. Diff Lat. : : Radius .. Diſtance required.
AsS. 43d.05m. .. 390 Min. : : S.90d. .. 571 Min. from Z to a
50d.23m. .. 563 ———— ———— 731 from a to b
55d.50m. .. 782 ———— ———— 945 from b to c
59d.32m. .. 984 ———— ———— 1141 from c to d
60d.21m. .. 281 ———— ———— 323 from d to N

This may ſerve for a ſufficient Explanation of this *Problem*, the whole is in the Table following.

Places	*Places Latitude.*	*Meridional Parts*	*Mer. Diff. Lat*	*Difference of Longitude*	*Diff. of Latit.*	*Courſes from Place to Place*	*Diſtances of Places*
	d m	Min	Min	d m	d m	d m	Minutes
Z	50 00	2374					
			570	10 or 600	6.30	S 46.55 W	571
a	43.30	2904					
			725	10 or 600	9.23	S 39 37 W	731
b	34.07	2179					
			884	10 or 600	13.02	S 34 10 W	945
c	21.05	1295					
			1014	10 or 600	16.24	S 30 28 W	1142
d	04.41	281					
			281	2.40 *or* 160	4.41	S 29 29 W	323
N	00.00	c					
			The whole Diſtance is ——				3712

Caſe 3. The ſecond kind, ; *Both Places in North, or in South Latitude, as for* Example,

Problem 3. *Suppoſe the* Lizard *and Iſland* Barbadoes ; *I demand the Angles of Poſition ? The* Great Circle's *Diſtance between them ? The* Latitude *of the Arch at every* 10 *Degrees Difference of* Longitude ? *With the Courſe, and Diſtance from each of them, according to* Mercator ?

The Latitude and Longitude of theſe Places ſuppoſed as follows :

		d. m		d. m.
Lizard	Latit.	50.00	Longit.	5.24 W.
I. *Barbadoes*		13.00		58.04 W

And their Difference of Longitude is — 52.40 W

This *Problem* is delineated *Sterographically* by the Directions in *Problem* 7. of *Geography*, in pages 186 and 187.

In the *Oblique Spheric Triangle* PZL *Plate* 6, *Fig*, 2.

1. Z repreſents the *Lizard* in Latitude 50 Degrees North.
2. L The Iſland *Barbadoes*, in Latitude 13 Degrees North.
3. The Side PZ the Complement of the Latitude of the *Lizard* 40 Degrees.
4. The Side PL the Complement of the Latitude of *Barbadoes*, 77 Degrees.
5. The Angle ZPL their Difference of Longitude 52 Degrees 40m.

6. PZL	the Angle of Poſition at	the *Lizard*
7. PLZ		*Iſland Barbadoes*

8. The Side ZL the great Circles Diſtance between them.

For the Angle PZL and PLZ, (by *Chapter* 5. *Section* 5. *Problem* 9. *Caſe* 7, of *Spheric Trigonometry Oblique*, in *Pages* 144 and 145.) the Proportions are theſe;

As the Sine of half the Sum of the Complements of both Latitudes, is to the Sine of half their Difference;

So is the Tangent Complement of half their Difference of Longitude, to the Tangent of half their Difference of the Angle of Poſition. Again,

As the Sine Complement of half the Sum of the Complements of both Latitudes, is to the Sine Complement of half their Difference;

So is the Tangent Complement of half their Difference of Longitude, To the Tangent of half the Sum of the Angles of Poſition. But ſhorter thus,

As S. ½ *Sun ſides* ·· S. ½ *their diff.* : : T.c. ½ ZPL ·· T. ½ *diff. of Angles*
As S. 58d. 30m. ·· S. 18d. 30m. : : T. 63d. 40m. ·· T. 37d. 02m.

Again,

As Sc. ½ *Sum ſides* ·· S ½ *their diff.* : : T.c. ½ ZPL ·· T. ½ *Sum Angles*
As S. 31d. 30m. ·· S. 71d. 30m. : : T. 63d. 40m. ·· T. 74d. 48m.
To which the ½ Diff. above being added ——— 37d. 02m.
The Sum is the Angle of Poſition at Z ——— 111d. 50m.
And ſubtracted in the Angle of Poſition at L— 37d. 46m.

For the Side ZL, the Diſtance, it's found (by *Chapter* 7. *Section* 2. *Caſe* 3. *Problem* 7. of *Geography*, in *Pages* 187 and 188.) to be 56d. 23m. or 3383 Minutes, which is their Diſtance in the Arch of a great Circle.

To find the Latitudes by which the Arch ſhall paſs, at every 10 deg. Difference of Longitude, from Z repreſenting the *Lizard*

Lizard, deſcribe the Problem Gnomonically, and then all the parts of it will be Right Lines, which is thus done,

The Problem Gnomonically Delenated.

1. Make the Angle LPZ equal to 52d.40m the Difference of Longitude.

2. Make the Side PZ equal to the *Tangent* of 40 Degrees, the Complement of the *Lizard's* Latitude.

3. And P L equal to the *Tangent* of 77 Degrees the Complement of *Barbadoes* Latitude.

4. Draw the Line LZ, which is the Great Circle's Diſtance between them, and continue it beyond Z.

5. From P let fall the Parpendicular PB, to cut LZ in B; which being meaſured on the Scale of *Tangents*, is 36d. 38m. the Complement of the Arch's greateſt Latitude.

6. Then draw Lines from P, each 10 Degrees diſtant from Z; as P a, P c, P d, P e, and P f, which are Meridians, each 10 Deg. of Longitude from the *Lizard*, and from each other.

7. Meaſure P a, P c, *&c.* on the *Scale of Tangents*, and it ſheweth the Complement of the Latitudes of the Arch, at the reſpective Places, a, c, d, *&c.*

Theſe are found by Calculation after this manner:

Firſt. In the Rectangle Spheric Triangle P B Z; there is

$$\text{given the}\left\{\begin{array}{l}\text{Hypot. PZ 40d. 00m.}\\ \text{Angle PZB 68d. 10m.}\end{array}\right\}\text{to find the}\left\{\begin{array}{l}\text{Leg B P}\\ \text{Angle BPZ}\end{array}\right.$$

Which, by *Chapter* 5. *Section* 4. *Problem* 2. *Caſes* 4. and 6. of *Spheric Trigonometry Rectangular*, in Pages 136, and 137. Is thus,

1. For the Leg PB, the Complement of the Arches greateſt Latitude it's thus;

As the Radius is to the Sine Complement of the greateſt given Latitude;

So is the Sine of the Angle of Poſition (at that Place,) to the Sine Complement of the Arch's greateſt Latitude. That is,

As Radius . . S Hypot. PZ : : S. Angle PZB . . S. Leg PB.

As S. 90d. . . S. 40d. 00m. : : S. 68d. 10m. . . S. 36d. 38m. which being Subtracted from ——— —— ——— 90d. 00m.

Reſts the Arch's greateſt Latitude —— —— 53d. 22m.

2. For the Vertical Angle PBZ, it's thus;

As Radius, is to the Sine of the greateſt given Latitude;

So is the *Tangent* of the Angle of Poſition (at that Place,) to the *Tangent* of the Complement of the Vertigal Angle: That is,

As Radius ·· S c:Hyp. PZ : : T.Angle PZB ·· T c.Angle BPZ.
As S 90d. ·· S. 50d. 00m : : T. 68d. 10m. T62d. 23m which
being ſubtracted from —— —— —— 90d. 00m.
Reſts the Vertical Angle BPZ. —— 27d. 37m.

Secondly, to find the ſeveral Latitudes of the Arch at a, c, d, *&c.* you may conſider, that the ſeveral Prick'd Lines Pa, Pc, *&c.* are ſo many Hypotenuſes, to as many ſeveral *Rectangle Spheric Triangles* which have one common Leg P B, the Complement of the Arch's greateſt Latitude.

In each of them, there is given a Leg, and its adjacent Angle, to find the Hypotenuſe: that is, in the Triangle PBa, there is given the Leg PB, and Angle BPa; to find the Hypotenuſe, Pa; and ſo in all the reſt.

And the ſeveral Vertical Angles, B P a, B P c, B P d, *&c.* are found by a continual Addition of 10 Degrees, to the Angle BPZ, 27d. 37m. till the Sum exceed not 80d. 17m. the Difference of Longitude given, added to the foreſaid 27d. 37m. That is;

		d m
To the Angle BPZ		27.37
Add the Angle ZPa		10.00
Sum is the Ang:	BPa	37.37
	BPc	47.37
	BPd	57.37
	BPe	67.37
	BPf	77.37

Theſe Vertical Angles being thus found, the ſeveral Latitudes of the Arch at a, c, d, e, and f, are found by *Chapter* 5, *Section* 4. *Problem* 3. *Caſe* 9 *of Spheric Trigonometry Rectangular*, in *Pages* 137, and 138, the *Proportion* being the ſame as before, in *Caſe* 2. *Problem* 1. of this *Chapter*, in *Pages* 190, 193, and is as followeth.

As Radius, is to the Sine Complement of the Vertical Angles, So is the Tangent of the Arch's greateſt Latitude, to the Tangent of the Arch's Latiude required. Or thus;

AsRadius ·· SCo·BPa,BPc,*&c.* : : Tc·Leg BP ·· T.c. Pa,Pc, *&c.*
AsS.90d. ·· S. 52d 23m : : T.53d.22m. ·· T 46.49 — — a
42d.23m —— —— —— 42.11 —— c
32d·23m —— —— —— 35.46 Lat.of d
22d·23m —— —— —— 27 07 —— e
12d·23m —— —— 16.05 —— f

Which Latitude's Place in the Table following.

Thirdly,

Places	*Places Latitudes*	*Meridional Parts*	*Mer Diff Latit.*	*Difference of Longitude*	*Diff. of Latit.*	*Courſes from Place to Place.*	*Diſtances of Places*
	d m	Min	Min.	d m	d m	d m.	Min.
Z	50.00	3474					
a	46.49	3187	287	10 or 600	3.11	S.64.22 W	441
c	42.11	2796	391	10 or 600	4.38	S 56.55 W	509
d	35.46	2301	495	10 or 600	6.25	S 50 29 W	605
e	27.07	1691	610	10 or 600	8.39	S 44 32 W	728
f	16.05	978	713	10 or 600	11 02	S 40.05 W	865
L	13.00	787	191	2°40′ or 160	3.05	S 38 08 W	235
						The whole Diſtance ——	3383

Thirdly, The Courſe, and Diſtance in the two laſt Columns of this Table, are found by *Chapter* 4. *Section* 3. *Proolem* 2, of *Mercator's Sailing*, in *Pages* 93 and 94, in the ſame manner as in the two laſt *Problems* in this Chapter ; thus.

1. For the *Courſes*, the *Proportion* is.

As *Mer Diff.Lat.* ·· *Diff.Long.* :: *Radius* .. *T.of the Courſe* required
As 287 Min. ·· 600Min :: T.45d ·· T.64d 22m.SW.from Z to a
391 —— —— 56d 55m a to c
495 —— —— 50d 29m SW. c to d
610 —— —— 44d 32m from d to e
713 —— —— 40d 05m e to f
As 191Min ·· 160Min :: T45d... T.38d 08m f to L

2. For the Diſtances, the *Proportion* is,

As S c. *Courſe* ·· *Diff. Lat.* :: *Radius* ·· *Diſtance* required.
As S 25d 38m ·· 191 Min :: S 90d. .. 441 Min. from Z to a
33d 05m ·· 278 —— —— 509 a to c
39d 31m .. 385 —— —— 605 c to d
45d 28m .. 519 —— —— 728 from d to e
49d 55m ·· 662 —— —— 865 e to f
51d 52m ·· 185 —— —— 235 f to L

Thus is this *Third Problem* ſufficiently explained in every part of it.

Caſe 3. The Third Kind; *One Place in North Latitude, and the other in South Latitude, as for* Example.

Problem 4. *Suppoſe* Cape Cod *in* New England, *and* Cape Bona Eſperance : *I demand the Angle of Poſition ? The Great Circles Diſtance between them ? The Latitude of the Arch at every*

Degrees Difference of Longitude? the Courſe and Diſtance from *ccording to* Mercator?

e Latitude and Longitude of theſe Places ſuppoſed to be lows;

		D. M.		D. M.
Cod	Lat.	42 10 N.	Longit.	67 45 W.
Bon Eſper		34 25 S		17 10 E.

eir Differnece of Longitude ——— ——— 84 55 E.

he Oblique Spheric Triangle PZD, *Plate* 7. *Fig.* 1.

Z repreſents Cape *Cod* in Latitude 40d. 10m. North.

D Cape *Bon Eſperance*, in Latitude 34d. 15m. South.

he Side PZ the Complement of the Latitude of C. *Cod*, om.

The Side PD the diſtance of Cape *Bon Eſperance*, from rth Pole, or it's Latitude added to 90 Degrees equal 4d. 25 m.

The Ang. ZPD their Difference of Longitude, 84d. 55m.

PZD } the Angle of Poſition at Cape { *Cod*
PDZ } { *Bona Eſperance*

The Side ZD the Great Circles Diſtance between them.

the Angles P Z D, and P D Z, (*by Chapter* 5. *Section* 5 n 9. *Caſe* 7. in *Pages* 144 and 145, the *Proportion* are theſe;

d. m.			d. m.
PD 124 25		The Angle DPZ	84 55
PZ 47 50			
	d. m.	The half of it is	42 27
um 172 15	The $\frac{1}{2}$Sum 86 07	Which ſub. from	90 00
iff. 76 35	The $\frac{1}{2}$Diff. 38 17	Its Complement	47 33

Sum ſides .. S $\frac{1}{2}$*their Diff.* : : T. c. $\frac{1}{2}$ZPD .. T $\frac{1}{2}$ *Diff. Angles* req
86d. 07m. .. S. 38d. 17m. : : T. 47d. 33m. .. T 34d. 10m.
03d. 53m. .. S. 51d 43m. ——— ——— T 85d. 29m.

ded, giveth the greater Angle PZD ——— 119d. 39m

tracted is the leſſer Angle PZD ——— 51d. 19m.

e Diſtance ZD is found (by *Chapter* 5. *Section* 2. *Caſe* 3, n 8, of *Geography*) in *Pages* 188 and 189, to be 108d. or 6539 Minutes.

find the Latitudes by which the Arch ſhall paſs, at each egrees Difference of Longitude from Z, repreſenting *Cod*; deſcribe the *Problem Stereographically* on the *Plane* of *quator*, and then all the Meridians will be Right Circles.

o delineate the Problem Stereographically, *Plate* 6. *Fig.* 3.

1. De-

Places	Places Latitudes	Meridional Parts	Mer Diff Latit	Difference of Longitude	Diff. of Latit.	Courſes from Place to Place.	L
	d m	Min	Min.	d m	d m	d m.	M
Z	50.00	3474					
a	46 49	3187	287	10 or 600	3.11	S.64.22 W	
c	42.11	2796	391	10 or 600	4.38	S 56.55 W	
d	35.46	2301	495	10 or 600	6.25	S 50 29 W	
e	27.07	1691	610	10 or 600	8.39	S 44 32 W	
t	16.05	978	713	10 or 600	11 02	S 40.05 W	
L	13.00	787	191	2°40′or 160	3.05	S 38 08 W	
					The whole Diſtance ——		3

Thirdly, The Courſe, and Diſtance in the two laſt C of this Table, are found by *Chapter* 4. *Section* 3. *Proolem* *Mercator's Sailing*, in *Pages* 93 and 94, in the ſame man in the two laſt *Problems* in this Chapter ; thus.

1. For the *Courſes*, the *Proportion* is.

As *Mer Diff.Lat.* ·· *Diff.Long.* :: *Radius* .. T.*of the Courſe* re
As 287 Min. ·· 600Min :: T.45d. ·· T.64d 22m.SW.fro
391 ———— ———— 56d 55m
495 ———— ———— 50d 29m
610 ———— ———— 44d 32m
713 ———— ———— 40d 05m
As 191Min ·· 160Min :: T45d.. T.38d 08m
} SW. from

2. For the Diſtances, the *Proportion* is,

As S c. *Courſe* ·· *Diff. Lat.* :: *Radius* ·· *Diſtance* required
As S 25d 38m ·· 191 Min :: S 90d. .. 441 Min. from Z
33d 05m ·· 278 ———— ———— 509
39d 31m .. 385 ———— ———— 605
45d 28m .. 519 ———— ———— 728
49d 55m ·· 662 ———— ———— 865
51d 52m ·· 185 ———— ———— 235
} from { a c d e t

Thus is this *Third Problem* ſufficiently explained in part of it.

Caſe 3. The Third Kind; *One Place in North Latitude, a other in South Latitude, as for* Example.

Problem 4. *Suppoſe* Cape Cod *in* New England, *and* Bona Eſperance : *I demand the Angle of Poſition ? The Circles Diſtance between them ? The Latitude of the Arch a* *ry* 10 *Degrees Difference of Longitude? the Courſe and Diſtance from them according to* Mercator?

The Latitude and Longitude of theſe Places ſuppoſed to be as follows;

		D. M.		D. M.
Cape *Cod*	Lat.	42 10 N.	Longit.	67 45 W.
Cape *Bon Eſper*		34 25 S		17 10 E.
Their Differnece of Longitude				84 55 E.

In the Oblique Spheric Triangle PZD, *Plate* 7. *Fig.* 1.

1. Z repreſents Cape *Cod* in Latitude 40d. 10m. North.
2. D Cape *Bon Eſperance*, in Latitude 34d. 15m. South.
3. The Side PZ the Complement of the Latitude of C. *Cod*, 47d. 50m.
4. The Side PD the diſtance of Cape *Bon Eſperance*, from the North Pole, or it's Latitude added to 90 Degrees equal to 124d. 25 m.
5. The Ang. ZPD their Difference of Longitude, 84d. 55m.
6. PZD } the Angle of Poſition at Cape { *Cod*
7. PDZ } the Angle of Poſition at Cape { *Bona Eſperance*
8. The Side ZD the Great Circles Diſtance between them.

For the Angles P Z D, and P D Z, (*by Chapter* 5. *Section* 5 *Problem* 9. *Caſe* 7. in *Pages* 144 and 145, the *Proportion* are theſe;

	d. m.		d. m.
Side PD	124 25	The Angle DPZ	84 55
Side PZ	47 50		
	d. m.	The half of it is	42 27
The Sum 172 15 The $\frac{1}{2}$Sum	86 07	Which ſub. from	90 00
The Diff. 76 35 The $\frac{1}{2}$Diff.	38 17	Its Complement	47 33

As S. $\frac{1}{2}$*Sum ſides* ·· S $\frac{1}{2}$*their Diff.* : : T.c. $\frac{1}{2}$ZPD ·· T $\frac{1}{2}$*Diff. Angles* req

As S .86d. 07m. ·· S. 38d. 17m. : : T. 47d. 33m. ·· T 34d. 10m.

As S, 03d. 53m. ·· S. 51d 43m. ———— ——— T 85d. 29m.

Added, giveth the greater Angle PZD ———— 119d. 39m

Subtracted is the leſſer Angle PZD ———— 51d. 19m.

The Diſtance ZD is found (by *Chapter* 5. *Section* 2. *Caſe* 3, *Problem* 8, of *Geography*) in *Pages* 188 and 189, to be 108d. 59m. or 6539 Minutes.

To find the Latitudes by which the Arch ſhall paſs, at each 10 Degrees Difference of Longitude from Z, repreſenting Cape *Cod*; deſcribe the *Problem Stereographically* on the *Plane* of the *Equator*, and then all the Meridians will be Right Circles.

To delineate the Problem Stereographically, Plate 6. *Fig.* 3.

1. Deſcribe the Primitive Circle and make the Angle DPZ equal to 84d. 55m. the Difference of Longitude by *Chapter* 5. *Section* 1. *Problem* 2. *Caſe* 2. (in Page 112) of *Spheric Geometry*, by drawing two Right Circles.

2. Make the Side PZ equal to the Half-Tangent of 47d. 50m. the Complement of the Latitude of Cape *Cod*.

3. And PD equal to the Half-Tangent of 124d. 25m. (the Latitude of Cape *Bon Eſperance* added to 90d) by *Chap.* 5. *Sect.* 1. *Prob.* 6. *Caſe* 2 of *Spheric Geometry*, in Pages 116 and 117.

4 Then by *Chapter* 5. *Section* 1. *Problem* 4. of *Spheric Geometry* (in Pages 113 and 114) through Z and D draw a Great-Circle.

5. From P (by *Problem* 5. of *Spheric Geometry* in Page 114) let fall the Perpendicular PB, to cut ZD in B; which being meaſured on the Scale of *Half-Tangents*, is 40d, 06m the Complement of the Arch's greateſt Latitude

6. Then draw Lines from P, each 10d. diſtant from Z; as Pa, Pc, Pd, Pe, *&c.* which are Meridians each 10d. of *Longitude* from one another, and from the Meridian of Cape *Cod*.

7. Meaſure Pa, Pc, *&c*, on the Scale of Half-Tangents, and it ſheweth the Complement of the Latitude's of the Arch at the reſpective Places a, c, d, *&c.*

Theſe are found by Calculation after this manner, which is in all reſpects like the Work of the laſt Problem.

Firſt, In the Rectangle Spheric Triangle PBZ.

1. For the Leg BP, the Complement of the Arch's greateſt Latitude it's thus;

As Radius .. S. Hypot PZ : : S. Angle PZB .. S. Leg PB
As S 90d. .. S. 47d. 50m. : : S. 61d. 21m. .. S. 40d. 06m.
Which ſubtract from ——— 90d. 00m.

Reſts the Arch's greateſt Latitude ——— 49d. 54m.

2. For the Vertical Angle PZB it's thus;

As Radius .. S.c. Hypot. PZ : : T. Angle PZB .. T.c. Angle BPZ
As S. 90d. .. S. 42d, 10m. : : T. 61d. 21m. .. T. 49d. 13m.
Which ſubtracted from ——— 90d. 00m

Reſts the Vertical Angle BPZ ——— 40d. 18m.

Secondly, For the ſeveral Latitudes at a, c, d, *&c.* add 10d. to the Angle BPZ (in Continuation) Eight times, which produceth the ſeveral Vertical Angles, BPa, BPc, BPd, *&c.*

To

		d.m.
To the Angle BPZ		40.18
Add the Angle ZPa		10.00
Sum is the Angle	BPa	50.18
	BPc	60.18
	BPd	70.18
	BPe	80.18
	BPf	90.18
	BPg	100.18
	BPh	110.18
	BPi	120.18

Theſe Vertical Angles being thus found, the ſeveral Latitudes of the Arch, at a, c, d, e, f, g, h, and i, are found by *Chapter* 5. *Section* 4. *Problem* 3. *Caſe* 9, *of Spheric Trigonometry Rectangular*; the Proportions being the ſame as before in *Caſe* 2. *Problem* 1. of this *Chapter*, in *pages* 193, and 194, as follows.

As the Radius, to the Sine Complement of the Vertical Angle; So is the Tangent of the Arch's greateſt Latitude, to the Tangent of the Arch's Latitude required. Or thus,

AsRadius .. S.c.BPa,BPc,&c. :: Tc.LegBP .. Tc.Pa,Pc,Pd,&c.

			d. m.		
As S.90d. ..	S. 39d.42m ::	T. 49d. 54m. ..	T. 37.11		a
	29d.42m		30.26	Latitude of	c
	19d.42m		21.49		d
	09d.42m		11.19		e
	00d.18m		00.21		f
	10d.18m		11.59		g
	20d.18m		22.23		h
	30d.18m		30.56		i

Thirdly, For the Courſes, and Diſtances, they are found by *Chapter* 4. *Section* 3. *Problem* 2, *of Mercator's Sailing*, in *Pages* 93, and 94, as follows,

For the Courſes, the Proportion is,

Mer. Diff. Lat. .. Diff. Long. :: Radius .. T. Courſe

As389Min. ..	600Min. ::	T.45d. ..	T.57d.03m	SE.	from Z to a
485			51d.03m	S E. from	a to c
578			46d.04m		c to d
660			42d.16m		d to e
704			40d.26m		e to f
702			40d.31m		f to g
655			42d.30m		g to h
574			46d.16m		h to i
As346Min. ..	295Min. ::	T.45d. ..	T.49d.59m		i to D

For

2. For the Diſtances, the Proportion is
As Sc. Courſe ·· Diff. Lat. : : Radius .. Diſtance required.
As S. 32d. 57m ·· 299 min. : : S. 90d. ·· 550 Min. from Z to a.
38d. 57m. ·· 403 ——— ——— 941 a to c
43d. 56m. ·· 519 ——— ——— 748 c to d
47d. 44m. ·· 630 ——— ——— 851 d to e
49d. 34m. ·· 700 ——— ——— 920 e to f
49d. 29m. ·· 698 ——— ——— 918 from f to g
47d. 30m. ·· 624 ——— ——— 847 g to h
43d. 44m. ·· 513 ——— ——— 724 h to i
75d. 10m. ·· 209 ——— ——— 324 i to D
Which place orderly as in the Table following and its finiſh'd

Places	Places Latitude	Meridian Part	Mer. Diff. Lat.	Difference of Longitude	Difference of Latitude	Courſes from Place to Place	Diſt. of Places
	d m	Min	Min.	d m	d m m.	d m	Min
Z	42.10N	2795					
a	37 11	2406	389	10 or 600	4.59or299	S 57 03 E	551
c	30.28	1921	485	10 or 600	6 43or403	S 51.03 E	641
d	21.49	1343	578	10 or 600	8.39or519	S 46.04 E	748
e	11.19N	683	660	10 or 600	10.34or630	S 42 16 E	851
f	00:21 S	21	704	10 or 600	11.40or700	S 40 26 E	920
g	11-59	724	703	10 or 600	11.38or698	S 40 31 E	918
h	22.23	1379	655	10 or 600	10.24or624	S 42 30 E	847
i	20.56	1953	574	10 or 600	8.33or513	S 46 16 E	742
D	34.25 S	2202	249	4.55 or 295	3.29or209	S 49 50 E	324
			The whole Diſtance is				6541

Note; The Arch of a great Circle may be deſcrib'd on a *Mercator's Chart*, and thereby much of the Calculative Work may be ſpared; for having the ſeveral Latitudes of the Arch at every 5, or 10 Degrees Difference of Longitude, (by *Chapter* 4. *Section* 1. *Problems* 1 and 2, of the *Uſe of Mercator's-Chart*, in *Pages* 84 and 85,) thoſe Places may be prick'd down in the *Chart*, and then with a Black-Lead Pencil draw Lines from place to place, which will repreſent the Great Circle, and by *Problems* 3 and 4, of the *Uſes* of that *Chart*, in *Page* 85, the

Plate: 6

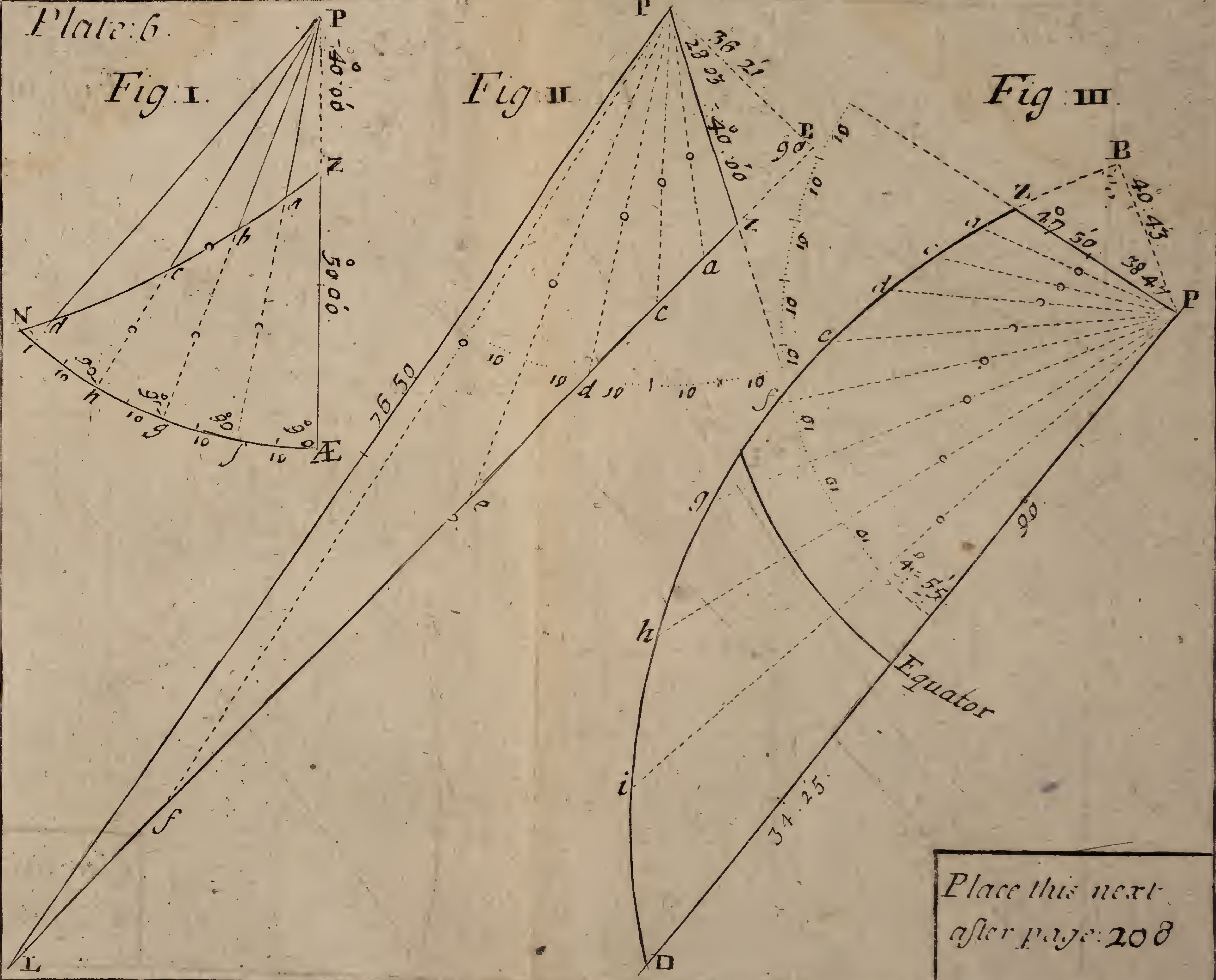


Fig. I.

Fig. II.

Fig. III.

Place this next after page: 208

the Courſes, and Diſtances from each other may be found, and at any time thoſe Lines may be wiped out, and the Chart as fit to ſerve at any other time as before.

So that any *Problem*, being thus drawn, in a *Mercator's Chart*, the nearer the Ship ſails to it, the nearer to a *Great Circle* ſhe makes her way good, and conſequently the ſhorter her Paſſage, the only thing *Great-Circle-Sailing*, is uſeful for, of which I have ſaid enough to explain it.

Thus is finiſhed the *Third Part of Navigation*, Or the *Third Kind of Sailing*, and now we paſs on to *Aſtronomy*.

CHAP. IX. *Spheric Trigonometry applied in ſundry* Aſtronomical Problems, *uſeful in the Art of Navigation.*

WHAT a *Sphere* or *Globe* is, and the Circles generally drawn on it hath been taught (*Chapter 6, Section* 2, and 3.) in the Deſcription of both Globes: But how theſe are drawn on a Plane, and form divers Triangles, from whence Multitudes of uſeful and pleaſant *Problems* may be framed, is our preſent Work.

Section I. *Aſtronomical Definitions.*

THE *Circles* drawn upon the Sphere's Surface, are either Great or Leſſer Circles.

I. The Great Circles, and their Poles deſcribed,

Great Circles, are thoſe which divide the Globe, or Sphere into two equal Parts, and are principally theſe ſix; the Equinoctial, Ecliptic, Meridian, Horizon, Azimuth, and Circle of Longitude.

1. The *Equinoctial* is a Great Circle which lies in the Middle, between the two Poles of the World, and conſequently each Pole is 90 degrees diſtant from it, cutting all Meridians at Right Angles, and divides the World into the Northern and Southern Hemiſpheres, as the Right Circle ÆAQ. *Plate* 7. *Fig.* 1 and 2.

The Poles of the World are two fixed Points in the Heavens, diametrically oppoſite to each other, the one in the *Northern Hemiſphere*, called the (Artic or) North Pole, the other in the *South Hemiſphere*, called the (Antartic or) South Pole, as P and I; *Plate* 7. *Fig.* 1 and 2.

The *Axis* of the World, is an immaginary Line drawn from Pole to Pole, about which the Diurnal Motion (as ſuppoſed) from Eaſt to Weſt, is performed; as PAI.

2. The *Ecliptic* (is a great Circle) croſſing the Equinoctial in (two oppoſite Points, the beginning of *Aries* and *Libra*, making an (Angle called its Obliquity) of 23d. 30m. as the Right Circle, by ♋A♑. *Plate* 7. *Figure* 1.

This Circle is divided into Twelve equal Parts called Signs, each containing 30deg. whoſe Names and Characters follow.

Aries	♈	called Northern Signs	*Libra*	♎	called Southern Signs
Taurus	♉		*Scorpio*	♏	
Gemini	♊		*Sagittarius*	♐	
Cancer	♋		*Capricornus*	♑	
Leo	♌		*Aquarius*	♒	
Virgo	♍		*Piſces*	♓	

The Zodaick, is a Zone or Girdle, having Eight Degrees of Latitude on each ſide the Ecliptic; in which ſpace, the Planets make their Revolutions, being divided and diſtinguiſhed by the twelve Signs.

The *Poles of the Ecliptic*, are two oppoſite Points 23d. 30m. diſtant from the Poles of the World; as K, and L.

3. The *Meridians* (are great Circles) paſſing through both Poles of the World, and croſſeth the Equinoctial at Right Angles, as PÆI, and PMI, *&c. Plate* 7. *Fig.* 1 and 2.

The *Colures*, are two Meridians dividing the Equinoctial and Ecliptic into four equal Parts; one of theſe paſſeth by the Equinoctial Points, *Aries* and *Libra*, and is called the Equinoctial Colure, as PAI. *Plate* 7. *Figures* 1, and 2.

The other paſſeth by the beginning of Cancer and Capricorn, and is called the *Solſtitial Colure*; as P ♋ ÆI ♑ Q: *Plate* 7. *Figure* 1.

The *Sun's Meridian*, is that Meridian which paſſeth over the Sun's Center.

A Star's Meridian, is that Meridian which paſſeth thro' the middle of that Star.

4. The *Horizon* is a great Circle 90 Degrees diſtant from the Zenith and Nadir, cutting all Azimuths at Right Angles, and dividing the World into two eqnal Parts, the upper and viſible Hemiſphere, and the lower and inviſible Hemiſphere. This Circle is repreſented by the Right Circle S A B. *Plate* 7. *Fig.* 2.

The *Zenith* and *Nadir*, are two Points diametrically oppoſite, and are the Poles of the Horizon: The Zenith is the Vertical Point, or Point right over our Heads as Z: The Nadir is directly oppoſite thereto, as N. *Plate* 7. *Fig.* 2.

5. The *Azimuth*, or *Vertical Circles*, (are great Circles) concurring and interſecting each other in the Zenith, and Nadir,

and croſs the Horizon at Right-angles, as ZCN, and ZAN, &c.

The *Prime Vertical*, is that Azimuth Circle, which paſſeth through the Eaſt and Weſt Points of the Horizon, as the Right Circle ZAN.

The *Meridian of a Place*, is that Meridian which paſſeth thro' the Poles of the World, and the Zenith and Nadir of the ſaid Place, as Z P B N I S Æ Z, *Plate* 7, *Figure* 2.

6. Circles of Longitude, (are great Circles) interſecting each other in the Poles of the Ecliptic, as K A L, and K ♈ L; *Plate* 7. *Figure* 1.

II. *The Leſſer Circles defined.*

Leſſer or *Small Circles*, are thoſe which divide the Sphere into two equal Parts, and are drawn parallel to ſome great Circle; and therefore are called Parallel Circles; and are of three kinds, *viz.* *Parallels of Declination*, *Parallels of Latitude*, and *Parallels of Altitude*.

1. *Parallels of Declination*, (are ſmall Circles) parallel to the Equinoctial, imagined to paſs thro' every Degree and Minute of the Meridian, between the Equinoctial and each Pole of the World, as ♋ f g, and ♑ h i. *Plate* 7. *Figures* 1 and 2.

The *Tropic's* are two Parallels of Declination 23d. 30m. diſtant from the Equinoctial, limiting the Sun's greateſt Declination.

The *North Tropic*, paſſeth by the beginning of Cancer and is called the *Tropic of Cancer*; as ♋ f g. *Plate* 7. *Fig.* 1, and 2.

The *South Tropic*, paſſeth by the beginning of Capricorn, and is called the *Tropic of Capricorn*; as ♑ h i. *Plate* 7. *Figures* 1, and 2.

The Polar Circles are two Parallels of Declination, 66d. 30m. diſtant from the Equinoctial, and 23d. 30m. from each Pole of the World.

That which is adjacent to the North Pole is called the *Artic Circle*; as K n o: and the other the Antartic Circle; as L p r, *Plate* 7. *Figures* 1 and 2.

2. Parallels of Latitude are (Small Circles) parallel to the Ecliptic, imagined to paſs through every Degree and Minute of the Colures, between the Ecliptic and the Poles thereof as w x y.

3. *Almicanthers*, or Parallels of Altitude, are ſmall Circles parallel to the Horizon, imagin'd to paſs through every Degree and Minute of the Meridian, between the Horizon and the Zenith; as *a* l t. *Plate* 7. *Figure* 2.

Theſe Definitions compar'd with *Chapter 6. Section* 4. (*of the Uſe of the* Celeſtial Globe, in Pages 168, and 169.) and well conſider'd, will make way for the underſtanding the following Problems.

Sect. II. *Spheric Trigonometry Rectangular, applied in Aſtronomical Problems, uſeful in Navigation.*

AND becauſe the Sun's Place in the Ecliptic, is the ground of the ſucceding Problems, you have here (out of Mr. *Tho. Street's Memorial Verſes on the* Eccleſiaſtical and Civil Kalendar) a General Rule; which for common Uſes may ſerve, and is as follows.

1. *To know the Day of the Month the Sun entereth any of the* Twelve Signs.

The Rule, Twice 9, twice 10, 4 Twelves, 11;
Then 10; then 9, then 8 or 7:

That is, counting *March* the firſt Month, the Sun enters

♈ *March*	9	♌ *July* ———	12	♐ *November*	11
♉ *April*	9	♍ *Auguſt* ——	12	♑ *December*	10
♊ *May*	10	♎ *September*	12	♒ *January*	9
♋ *June*	10	♏ *October*	12	♓ *February*	8

2. *To find the Degree of the Sun's Place on any given Day.*

The Rule. From the Day of the Month given (if you can) ſubtract the Day of his Entrance into the *Sign* of that Month, the Remainder is the Degree of the Sun's Place in that *Sign*. Or elſe,

When you can't ſubtract, add 30 to the Day given, and from the Sum ſubtract the Day of the Entrance into the *Sign* of that Month, the Remainder ſhall be the Degree of his Place in the *Sign* preceeding the Month given.

Example, 1. *March* 20th, I deſire to know the *Sun's* Place?

From *March* the 20th, the Day given, ſubtract the Sun's Entrance ♈ *March* 9.

The Remainder 11 is the Degree of the Sun's Place in ♈

Example 2. *May* the 4*th*, I deſire to know the Sun's Place?

To the Day given *May* the 4
Add ——— —— ——— 30
Sum is ——— ——— ——— 34 from which
Subtract the *Sun's* Entr. into ♊ *May* 10
Remainder is the *Sun's* Place ♉ —— 24 Degrees

Problem 1. The Sun's Place in the Ecliptic, and his greateſt Declination given; to find his Right Aſcenſion, and preſent Declination.

Definition 1. *Aſcenſion*, is the Riſing of the Sun, Star or any part of the Equinoctial above the Horizon; and Deſcenſion is the Setting thereof.

2. *Right Aſcenſion*, is an Arch of the Equinoctial, intercepted between the beginning of ♈, and any Meridian, and counted according to the Order or Succeſſion of the Signs: Or, it's that Degree and Minute of the Equinoctial (counted as before) which cometh to the Meridian with the Sun, Star, or with any part of the Ecliptic; as AM. *Plate* 7. *Fig.* 1.

3. *Declination*, is an Arch of a Meridian contained between the Sun, or Star's Center, and the Equinoctial, as MC.

4. The Sun's greateſt Declination is an Arch of the Solſtitial Colure, counted between the Equinoctial and the Ecliptic, and is 23d. 30m. as *Æ* ♋; and Q ♑. *Plate* 7. *Fig.* 1.

Example. The Sun in *Taurus*, 24d. 15m. I demand his Right Aſcenſion, and Declination.

In the Rectangle Spheric Triangle AMC. *Plate* 7. *Fig.* 1.

1. AMC the Right Angle.
2. AC the Sun's Longitude from the next Equinoctial Point
3. AM his Right Aſcenſion from the ſame Point.
4. MAC the Sun's greateſt Declination equal to 23d. 30m.
5. MC his preſent Declination.

Note; The Sun in ♈, ♉, ♊, ♑, ♒, ♓, the neareſt Equinoctial Point is the beginning of ♈: But when the Sun is in ♋, ♌, ♍, ♎, ♏, or ♐, the neareſt Equinoctial Point is ♎. So that in this Problem the Sun being in ♉ 24d. 15m. he is 54d. 15m. from the neareſt Equinoctial Point ♈.

To project this *Problem Sterographically* on the Plain of the Solſtitial Colure:

1. Deſcribe the Primitive Circle with a Chord of 60 Degrees, and quarter it, with two Right Circles, ÆAQ (the Equinoctial) and PAI (the Equinoctial Colure) placing A at the Center of the Primitive Circle, which now is the Solſtitial Colure.

2. Make (by *Problem* 2. *Caſe* 1. *of Spheric Geometry*, in Page 112) the Angle ÆA♋ equal to 23d. 30m. (the Sun's greateſt Declination) by laying the Chord of it, from Æ to ♋, and drawing the Right Circle ♋A♑ the Ecliptic.

3. The Ecliptic is divided into the 12 Signs, each being 30d. from the Scale of Half-Tangents, by *Problem* 6. *Caſe* 2. *of Spherical Geometry* in Pages 116 and 117.

4. On the Ecliptic make AC equal to 54d. 15m. from th Scale of Half-Tangents by the ſame *Problem 6. Caſe 2.*

5. Then (by *Chapter 5. Section 1.*) *Problem 5. Caſe 3. of Spheric Geometry*, in Page 115, draw from C a great Circle perpendicular to ÆAQ, as is the Oblique Circle PCMI, to cut ÆAQ in M, and its done.

For in the Rectangle Spheric Triangle AMC, the Legs AM, and MC are the two Things required, and may be meaſured by *Chapter 5. Section 1. Problem 7. Caſes* 2 and 3. *of Spheric Geometry.* in Page 118.

But by *Spheric Trigonometry*, having the Hypotenuſe and one Angle given, the Proportions are as follow.

1. To find the Sun's Right Aſcenſion, by *Chapter 5. Section 4. Problem 2. Caſe 5. of Spheric Trigonometry Rectangular*, in Pages 136 and 137, it's thus;

As the Radius is to the Sine Complement of the Sun's greateſt Declination;

So is the Tangent of the Sun's Longitude from the neareſt Equinoctial Point, to the Tangent of his Right Aſcenſion, from the ſaid Point, Or thus;

As Radius .. S.c Angle MAC :: T. Hypot. AC .. T. Leg AM.
As S. 90d. .. S. 66d. 30m. :: T. 54d. 15m. .. T. 51d. 52m.

Note; This Proportion finds the Sun's Right Aſcenſion only when he is in the firſt Quarter of the Ecliptic; that is, in ♈, ♉, or ♊: But when the Sun is in the ſecond Quarter ♋, ♌, or ♍, it muſt be ſubtracted from 180d. and when he is in ♎, ♏, or ♐, it muſt be added to 180d. and in the laſt Quarter ♑, ♒ or ♓, that found by this Propotion, muſt be ſubtracted from 360d. and ſo will you have the Sun's Right Aſcenſion from ♈ (for any Place in the Ecliptic) deſired.

2. To find the Sun's preſent Declination, by *Chapter 5: Section 4. Problem 2. Caſe 4. of Spheric Trigonometry Rectangular*, in Page 136, it's thus;

As the Radius is to the Sine of the Sun's Longitude from the neareſt Equinoctial Point;

So is the Sine of his greateſt Declination, to the Sine of the Sun's preſent Declination. Or thus;

As Radius .. S. Hypot. AC :: S. Angle MAC .. S. Leg CM.
As S. 90d. .. S. 54d. 15m. :: S. 23d 30m. .. S. 18d. 51m.

Note; The Sun being in any of the North Signs, ♈, ♉, ♊. ♋, ♌, or ♍, his Declination is North; but when in any of the Southern Signs ♎, ♏, ♐, ♑, ♒, or ♓, his Declination is South.

In this Rectangle Spheric Triangle AMC (*Plate 7. Figure 1.*) may the two next ſucceeding *Problems* be reſolved *Prob*

Problem 2. *The* Sun's Right Aſcenſion *given; to find his place in the Ecliptic, and his Declination?*

Example. *The* Sun's Right Aſcenſion 128d. 9m. *where is his Place in the Ecliptic, and what is his Declination?*

Here is one Leg and its adjacent Angle given: to wit, the Leg AM 51d. 51m. the Right Aſcenſion (ſubtracted from 180d. and Angle MAC 23d. 30m. the Sun's greateſt Declination; which Triangle is made by *Problem 12. of Spheric Trigonometry Geometrical* in *page* 125. and its Solution is by *Chapter* 5. *Section* 4. *Problem* 3. Caſe 7, 8, and 9. *of Spheric Trigonometry Rectangular*, in Pages 137, and 138, thus;

1. For the Sun's Place in the Ecliptic, it's thus;

T. Leg AM .. *Radius* : : S.c. *Angle* MAC .. T.c. *Hipot.* AC or
As *Radius* .. S.c Ang. MAC : : T.c. Leg AM .. T.c. Hipot. AC req.
As S. 90d. .. S. 66d. 30m. : : T. 38d. 09m. .. T. 35d. 46m.
Which ſubtract from ———————— 90d. 00m.

Reſteth the Sun's Longitude ———— 54d. 14m. wanting of ♎, ſo that his Place is 5d. 46m. in ♌.

2. For his preſent Declination, it's thus;

As T.c. Angle MAC .. Radius : : S. Leg AM .. T. Leg MC, Or
As Radius .. S. Leg AM : : T. Angle MAC .. T. Leg MC.
S. 90d. .. S. 51d. 51m. : : T. 23d. 30m. .. T. 18d. 52m. the Sun's Declination North decreaſing.

Problem 3. *The* Sun's Declination *given; to find his* Place *in the* Ecliptic *and* Right Aſcenſion.

Example. *The* Sun's Declination 16d. 39m. *South increaſing: I demand his* Place *in the* Ecliptic, *and his* Right Aſcenſion.

Here is a Leg and its oppoſite Angle given; that is, the Angle MAC 23d. 30m. the Sun's greateſt Declination, and the Leg MC 16d. 39m. his preſent Declination, which Triangle is made by *Prob. 13. of Spheric Trigonometry Geometrical*, in *page* 126; whoſe *Solution* is by *Chap. 5. Sect. 4. Prob. 4. Caſe* 10 *and* 12. of *Spherical Trigonometry Rectangular*, in Pages 138 and 139, thus;

1. To find his Place in the *Ecliptic*, it's thus;

As S. Angle MAC .. Radius : : S. Leg MC .. S. Hipot. AC
As S. 23d. 30m. .. S. 90d. : : S. 16d. 39m. .. S. 45d. 56m. the Sun's Longitude beyond ♎, becauſe his Declination is South increaſing; ſo that the Sun's Place is 15d. 56m. in ♏.

2. For his *Right Aſcenſion* it's thus;

Radius .. T c. Angle MAC : : T. Leg MC : . S. Leg AM.
T. 45d. .. T. 66d. 30m. : : T. 16d 39m. .. S. 43d. 27m.
which add ———————— 180d. 00m.

The Sum is the *Sun's* Right Aſcenſion —— 223d. 27m. from ♈

Problem 4. *The Latitude of a Place, and the Sun's Declination given ; to find his Amplitude and Aſcenſional Difference.*

Definition 1. *Latitude* of a Place, or *Latitude* upon the Earth, is an Arch of the Meridian of that Place, contained between the Zenith (of that Place) and the Equinoctial, as ZÆ ; equal thereunto is the Height of the Pole above the Horizon, as BP. *Plate* 7. *Fig* 2.

2. *Amplitude*, is an Arch of the Horizon, contained between the Ecliptic and the Equinoctial, and ſheweth how far the Sun or any Star riſeth, or ſetteth from the Eaſt, or Weſt Points of the Horizon ; as AR, *Plate* 7. *Fig*. 2.

3. *Aſcenſional Difference*, is the Difference between the Right Aſcenſion, and the Oblique Aſcenſion, or Deſcenſion : Or it's an Arch of the Equinoctial contained between the Hour Circle of ſix a Clock, and that Meridian which paſſeth by the *Sun* or *Star*'s Center, or any Point of the Ecliptic, in their Riſing, or in their Setting.

4. *Oblique* { *Aſcenſion,* *Deſcenſion,* } is an Arch of the Equinoctial, contained between the beginning of ♈, and that part of the Equinoctial that { Riſeth Setteth } with the Center of the *Sun* or *Star*, or with any point, part, or portion of the *Ecliptic*, in an *Oblique Sphere.*

	d.	m.	*Example.*
Latitude	51	32	*North given ; What is his* Amplitude,
Sun's Dec.	23	30	Aſcenſ. Differ.

In the Rectangle Spheric Triangle PBR. *Plate* 7. *Fig*. 2.

1. PBR the Rectangle.
2. PB the Latitude, or Height of the Pole above the Horizon.
3. PR the Complement of the *Sun*'s Declination.
4. BR the Complement of the *Sun*'s Amplitude
5. BPR the Complement of the *Sun*'s Aſcenſional Difference

To project it Sterographically on the Plain of the Meridian.

1. The Primitive Circle being deſcribed and quartered as (formerly) with two Right Circles SAB the Horizon, and (ZAN) the Prime Vertical ; with A at its Center. *Plate* 7. *Fig*. 2.

2. On the *Primitive Circle* lay the Latitude 51d. 32m. from B to P, and from Z to Æ, (by *Problem* 6. *Caſe* 1. *of Spheric Geometry*, in page 116) and draw the two Right Circles PAI for the Axis of the World, and Hour-Circle of Six, and ÆAQ the Equinoctial.

3. Then (by *Problem* 9. *Caſe* 2. *of Spheric Geometry, in page* 121) draw ♋ ☉ l t R g parallel to ÆAQ at 23d. 3cm. the given Declination) from it, to cut the Horizon SAB in R, the Place of the *Sun*'s Riſing and Setting.

4. Through P, R, and I, draw an Oblique Circle and it's done: For in the Rectangle Spheric Triangle PBR, the Leg BR, and Angle BPR are the two Things required, and may be meaſured by *Problems* 7, and 8, of *Spheric Geometry*, in *pages* 117, 118, and 119.

But by Trigonometry, having the Hypothenuſe PR *66*d. 30m. and Leg BP 51d. 32m. given, the Proportions by *Chap.* 5. *Section* 4. *Problem* 1. *Caſe* 1, and 3. of *Spheric Trigonometry Rectangular*, in pages 135 and 136, is thus:

1. To find the *Sun's Amplitude*, the Proportion is,

As the Sine Complement of the Latitude, is to the Radius,

So is the Sine of the *Sun*'s Declination, to the Sine of his Amplitude. Or thus;

As S.c. Leg BP .. Radius : : S.c. Hyp. PR .. S.c. Leg BR.

As S 38d, 28m. .. S. 90d. : : S. 23d. 30m. .. S. 39d, 52m.

Note, The Amplitude and Declination are ever of one Name; that is, both North or both South.

2. To find the Aſcenſional Difference, the Proportion is;

As the Radius, is to the Tangent of the Latitude;

So is the Tangent of the *Sun*'s Declination, to the Sine of the *Sun*'s Aſcenſional Difference. Or thus;

As Radius .. T. Leg BP : : T. c. Hyp. PR .. S.c. Angle BPR.

As T.45d .. T.51d.32m : : T. 23d. 30m. .. S. 33d. 11m. the Sun's Aſcenſional Difference.

Problem 5. *The Latitude of a Place, and the Sun's Declination given; to find the Oblique Aſcenſion or Deſcenſion.*

The Rule. 1. Find the Right Aſcenſion by *Problem* 3. and the Aſcenſional Difference by *Problem* 4. Then,

2. When the Latitude and Declination are both North, or both South, the Aſcenſional Difference added to, and ſubtracted from the Sun's Right Aſcenſion, the firſt is the Oblique Deſcenſion, the latter the Oblique Aſcenſion.

3. When the Latitude and Declination is one North, and the other South, add, and ſubtract as before; the firſt is the Oblique Aſcenſion, and the latter is the Oblique Deſcenſion.

Note; When you cannot ſubtract, add 360 Degrees to the Right Aſcenſion, and then ſubtract, alſo when you have added, if the Sum exceed 360 Degrees, ſubtract 360 Degrees therefrom, the Remainder is the Thing required.

Example. *Latit.* 51d. 32m. North——— } *given, what is*
Sun's Declin. 15d. 40m. South *decreaſing* }
his Oblique Aſcenſion *and* Deſcenſion ?

1. For his Right Aſcenſion, it's thus ;
As Radius ·· T.c. Angle MAC : : T. Leg MC ·· S. Leg AM
As T. 45d. ·· T. 66d. 30m. : : T. 15d. 40m. ·· S. 40d. 04m.
Which ſubtracted from——— ——— 360d 00m.
Remainder is the Sun's Right Aſcenſion ——319d. 56fro ♈

2. For his *Aſcenſional Difference*, it's thus ;
As Radius ·· T.Latitude : : T. Declin. ·· S.☉ Aſcenſional Dif.
As T.45d. ·· T.51d.32m. : : T. 15d. 40m. ·· S. 20 41
Right Aſcenſion before found —— 319 56 from ♈
Added is the Oblique Deſcenſion——340 37
Subtracted is the Oblique Aſcenſion—— 299 15

Problem 6. *The Latitude and the Sun's Declination given; to find the* Sun's Riſing *and* Setting; *and the Length of the Day or Night?*

The Rule. 1. Find the Sun's Aſcenſional Difference by *Problem* 4. in pages 216, and 217, which reduced into Time, by allowing as hereunder.

15d. 00m.	for	1 --- *Hour* ——	of Time ;
1d. 00m		0.04 *Minutes*	
0d. 15m.		0.01 *Minute*	

2. The Sun's Aſcenſional Difference (being reduced into Hours and Minutes) added to, and ſubtracted from ſix Hours, the one is *Sun-Riſing*, and the other is his *Setting*.

Note, When the Latitude, and Declination are both North, or both South; the Sun riſes before, and ſets after Six. But if one be North, and the other South ; he then riſes after, and ſets before Six of the Clock.

3. Double the Time of the Sun-Setting gives the Length of the Day, alſo double the Time of Sun-Riſing gives the Length of the Night.

Example. *In* Latitude 51d. 32m. North, *and the* Sun's Declination 23d. 30m. North ; the Sun's Aſcenſional Difference, *by* Problem 4. is 33d. 11m. *equal in Time to 2 Hours 13 Minutes. Therefore the Work is as follows.*

d. m. 6 Hours.
Aſcen. Diff. 33. 11. Or 2 13 h. m.
Add, is *Sun-Setting* 8.13 And Length of the Day 16.26
Subtract, is *Sun-Riſing* 3.47 And Length of the Night 7.34

In the ſame Rectangle Spheric Triangle P B R (*Plate* 7. *Figure* 2.) may the five next following Problems be reſolved; which is for the Learner's Exerciſe.

Problem 7. Latitude of a Place, and the Sun's Aſcenſional Difference given; to find his Declination and Amplitude.

Example. The { Latitude ——— 41d. 47m. South
{ Sun riſeth at —— 7d. 30m.

Here is a Leg and its adjacent Angle given; that is, the Leg BP 41d. 17m. the Latitude, and the Angle BPR 4h. 30m. or 67d: 30m. the Complement of the Sun's Aſcenſional Difference; which Triangle is made by *Prob.* 12. *of Spheric Trigonometry Geometrical, in Page* 125, and for its Solution, ſee *Chapter* 5, *Section* 4. *Problem* 3. *Caſes* 8 and 9, *of Spherical Trigonometry Rectangular*, in Pages 137 and 138, is thus;

1. For the Sun's Declination, it's thus;

As Radius ·· S. ⊙ Aſc. Diff. :: T.c. Latitude ·· T. ⊙ Decl. req.
As S. 90d ·· S. 22d. 30m. :: T. 48d. 13m. ·· T. 23d. 11m. N

2. For the Sun's Amplitude, its thus;

As T. ⊙ Aſc. Diff. ·· Radius :: S. Latitude ·· T.c. ⊙ Ampli. Or
As S. Latitude ·· Radius :: T.c. ⊙ Aſc. Diff. ·· T. ⊙ Amplit.
As S. 41d. 47m .. S. 90d. :: T. 22d. 30m. ·· T. 31d. 52m. N.

Problem 8. Latitude and Sun's Amplitude given; to find his Declination and Aſcenſional Difference.

Example. The { Latitude ——— 36d. 17m. North
{ Sun's Altitude —— 19d. 11m. South

Here are both the Legs given; that is the Leg SI 36d. 17m. the Latitude, and the Leg SR 70d. 49m. the Complement of the Sun's Amplitude; which Triangle is made by *Problem* 14. *of Spheric Trigonometry Geometrical*, in Page 127, and its Solution is by *Chapter* 5. *Section* 4. *Problem* 5. *Caſes* 13 and 14. of *Spheric Trigonometry Rectangular*, in Pages 139 and 140, in this manner.

1. For the Sun's Declination, thus;

As Radius ·· S.c. Latitude :: S. ⊙ Amplit. ·· S. ⊙ Declinat. req.
As S. 90d. ·· S. 53d. 43m. :: S. 19d. 11m. ·· S. 15d. 21m South

2. For his Aſcenſional Difference, thus;

As T.c. ⊙ Am. ·· Radius :: S. Latitude ·· T. ⊙ Aſc. Differ. Or,
As Radius ·· S. Latit :: T. ⊙ Amplit. ·· T. ⊙ Aſc. Differ.
As 90 deg. ·· S. 36° 17′ :: T. 19d. 11m. ·· T. 11d. 38m. or 0h. 47m

Problem 9. The Sun's Declination, and Amplitude given; to find the Latitude and Sun's Aſcenſional Difference.

Example. The Sun's { Declination ——— 19d. 10m. South.
{ Amplitude ——— 31d. 30m. South.

Here is the Hypotenuſe, and one Leg given; for which ſee *Problem* 10. *of Spheric Trigonometry Geometrical*, in *page* 123, and *Chapter* 5. *Section* 4. *Problem* 1. *Caſe* 2 and 3. of *Spheric Trigonometry Rectangular*, in *Pages* 135 and 136, for its Solution.

Note; The Latitude may be either North, or South, in this Problem.

Problem 10. Sun's Declination, and Aſcenſional Difference given; to find the Latitude, and his Amplitude.

Example. Sun { Declination ——— 23d. 30m. South
ſetteth at ——— 3h. 30m.

Here is the Hypotenuſe and one Angle given; for which ſee *Problem* 11. of *Spheric Trigonometry Geometrical*, *in Pages* 124 and 125, and *Chapter* 5. *Section* 4. *Problem* 2. *Caſes* 4 and 5. *of Spheric Trigonometry Rectangular*, in Pages 136 & 137. For its ſolution.

Problem 11. Sun's Amplitude, and Aſcenſional Difference given; to find the Latitude and his Declination.

Example. Sun { Amplitude ——— 33d. 20m. North
ſetteth at ——— 7h. 47m.

Here is one Leg, and its oppoſite Angle given, for which ſee *Problem* 13. of *Spheric Trigonometry Geometrical*, in Page 126, and *Chapter* 5. *Section* 4. *Problem* 4. *Caſes* 10 and 12, of *Spherical Trigonometry Rectangular*, in Pages 138 and 139. For the Proportions.

Problem 12. The Latitude of a Place, and the Sun's Declination given; to find his Altitude, and Azimuth at the Hour of Six.

Definition 1. Altitude is an Arch of an Azimuth Circle contained between the Horizon and any Parallel of Altitude; as b f. *Plate* 7. *Fig.* 2.

2. *Azimuth*, is an Arch of the Horizon, contained between the Meridian of the Place, and any Azimuth Circle. Or contained between the Prime Vertical and any other Azimuth Circle; as A b. *Plate* 7. *Fig.* 2.

Example. The { Latitude ——— 51d. 32m. } North
Sun's Declination ——— 23d. 30m. }

Note; At 6 of the Clock the Sun is upon the Axis PAI.

In the Rectangle Spheric Triangle A b f (*Plate* 7. *Fig.* 2.) is to be noted.

1. A b f the Rectangle.
2. b A f the Latitude of the Place.
3. A f the Sun's Declination, of the ſame Name with the Latitude.
4. b f the Sun's Altitude at the Hour of 6.

5. A b

5. Ab the Sun's Azimuth from the Eaſt at 6 in the Morning, and from the Weſt at 6 Afternoon: Northerly in North Latitudes, but Southerly in South Latitudes.

To project it Sterographically on the Plain of the Meridian.

1. Having deſcribed the Primitive Circle, quarter'd it, drawn the Axis of the World PAI, the Equinoctial Æ \Q, and the Parallel of Declination ♋☉ l t R g; as before directed in *Problem* 4. of this *Chapter*, in pages 216 and 217.

2. Through f (where the Parallel of Declination cutteth the Axis PAI) draw an Oblique Circle perpendicular to the Horizon SAB (by *Problem* 5. *Caſe* 3. *of Spheric Geometry*, in Pages 114 and 115) as is the Azimuth Circle Z f b N, to cut SAB in b, which forms the Rectangle Triangle A b f and it's done.

For the Leg Ab, the Sun's Azimuth, and the Leg b f the Sun's Altitude at 6 of the Clock, are the two things required, and are meaſured by *Problem* 7. *Caſes* 2 and 3. of *Spheric Geometry*. in Pages 117 and 118.

But by *Spheric Trigonometry*, having the Hypotenuſe and one Angle given, that is A f 23d. 30m. the Sun's Declination, and b A f 51d. 32m. the Latitude; the Leg b f the Sun's Altitude, and Leg A b his Azimuth at 6 of the Clock; are found by *Chapter* 5. *Section* 4. *Prolem* 2. *Caſes* 4 *and* 5. *of Spheric Trigonometry Rectangular*, in Pages 136 and 137

1. To find the Sun's Altitude at 6, the Proportion is;

As the Radius, is to the Sine of the Latitude; ſo is the Sine of the Sun's Declination, to the Sine of the Sun's Altitude, at the hour of 6. Or thus;

As Radius ·· S. Angle bAf : : S. Hypot. Af ·· S. Leg b f
As S. 90d. ·· S. 51d. 32m. : : S. 23d. 30m. ·· S. 18d. 12m.

2. To find the Sun's Azimuth, the Proportion by the aforeſaid Problem is.

As the Radius, is to the Sine Complement of the Latitude; ſo is the Tangent of the Sun's Declination to the Tangent of the Sun's Azimuth from the Eaſt, or Weſt, at the Hour of 6. Or thus.

As Radius ·· S c. Angle bAf : : T. Hypot Af ·· T. Leg A b.
As. S. 90d ·· S. 38d. 28m. : : T. 23d. 30m. ·· T. 15d. 08m.

That is,

At 6 in the Morning the Sun is E. 15d. 08m. N. or near upon the ENE. ¾ E. Point of the Compaſs. And at 6 Afternoon he is nearly upon the W N W. ¾ W. Point of the Compaſs.

In the ſame Triangle A b f (*Plate* 7. *Fig.* 2.) may be reſolved the five Problems next following; to exerciſe the young Learner.

Problem 13. The Latitude and Sun's Altitude at the Hour of Six given; to find his Declination and Azimuth.

Example. The { Latitude ——— ——— 35d. 20m. South.
Sun's Altitude ——— 9d. 50m. P M.

Here is one Leg and its oppoſite Angle given; that is, the Leg b f 9d. 50m. the Sun's Altitude, and the Angle b A f, 35d. 20m. the Latitude; which Triangle is made by *Problem* 13. of *Spheric Trigonometry Geometrical* in Page 126; and for its Solution, ſee *Chapter* 5. *Section* 4, *Problem* 4. *Caſes* 10 and 12, in Pages 138 and 139. And it's thus;

1. For the Sun's Declination, the Proportion is;
As S. Latitude .. Radius : : S. ⊙ Alt. at 6 .. S. ⊙ Declin. requi.
As S 35d. 20m. .. S. 90d : : S. 9d. 50m. .. S. 17d. 10m. South

2. For the Sun's Azimuth at 6, the Proportion is;
As Radius .. T c. Latitude : : T ⊙ Alt at 6 .. S. ⊙'s Azim. req.
As T. 45d. .. T. 54d. 40m. : : T. 9d. 50m. .. S. 14d. 9m. W. Southerly, or W S W. ¾ W. is the Point of the Compaſs the Sun is upon.

Problem 14. Latitude, and Sun's Azimuth at the Hour of ſix given; to find his Declination, and Altitude.

Example. The { Latitude ——— 36d. 19m. North.
Sun's Azimuth 10d. 14m. W. Northerly

Here is a Leg and its adjacent Angle given; that is, the Leg A b 10d. 14m, the Sun's Azimuth, and the Angle bAf 36d. 19m. the Latitude; which Triangle is made by *Problem* 12. of *Spheric Trigonometry Geometrical, in Page* 125, and for its Solution, ſee *Chapter* 5. *Section* 4. *Problem* 3. *Caſe* 7, and 9, in Pages 137 and 138. Which is thus;

1. For the Sun's Declination, the Proportion is;
As T. ⊙ Azim. .. Radius : : S. c. Latitude .. T. c. ⊙ Decli, Or;
As S c. Latitude .. Radius : : T. ⊙ Azimuth .. T. Declination
As S. 53d. 41m. .. S. 90d : : T. 10d. 14m .. T 12d. 38m. N.

2. For the Sun's Altitude at 6, the Proportion is;
As T c. Latitude .. Radius : : S. ⊙ Azim. .. T. ⊙ Altitude, Or;
As Radius .. S. Azimuth : : T. Latitude .. T. ⊙ Altit. at 6.
As S. 90d. .. S. 10d. 14m. : : T. 36d. 19m. T. 7d. 26m. Alt. at 6

Problem 15. *The* Sun's Declination *and* Altitude *at the Hour of ſix given; to find the* Latitude, *and his* Azimuth.

Example. Sun's { Declination 21d. 30m. South
Altitude —— 15d. 56m. A M.

Here is the Hypotenuſe and one Leg given ; that is, A f 21d. 30m. the Sun's Declination, and b f 15d. 56m. the ☉'s Altitude, for which ſee *Problem* 10. of *Spheric Trigonometry Geometrical*, in *page* 123. and *Chapter* 5. *Section* 4. *Problem* 1. *Caſes* 2 and 3. of *Spheric Trigonometry Rectangular* in *pages* 135 and 136.

Problem 16. Sun's Declination and His Azimuth at the Hour of ſix given ; to find the Latitude and his Altitude.

Example. Sun's { Declination 19d. 14m. South
Azimuth —— 10d. 09m. E. Southerly.

Here is (as in the laſt *Problem*) the Hypotenuſe and one Leg given ; that is, A f 19d. 24m. the Sun's Declination, and A b 10d. 09m. the ☉'s Azimuth ; for which ſee *Problem* 10. of *Spheric Trigonometry Geometrical, in page* 123. and *Chapter* 5. *Section* 4. *Problem* 1. *Caſes* 1 *and* 3. *of Spheric Trigonometry Rectangular, in pages* 135 *and* 136.

Problem 17. Sun's Azimuth and Altitude at the Hour of ſix given ; to find the Latitude and his Declination.

Example. Sun's { Azimuth —— 16d. 10m. W. Southerly
Altitude —— 9d. 00m.

Here are both Legs given ; for which ſee *Problem* 14. of *Spheric Trigonometry Geometrical, in page* 127. and *Chapter* 5. *Section* 4. *Problem* 5. *Caſes* 13 *and* 14. of *Spheric Trigonometry Rectangular*, in *pages* 139 *and* 140.

Problem 18. The Latitude of a Place, and the Sun's Declination given ; to find the Sun's Altitude and the Hour of the Day when the Sun is Eaſt, or Weſt.

Note ; When the Sun is either Eaſt, or Weſt, he is then upon the Prime Vertical, ZAN, in *Plate* 7 *Fig.* 2.

Example. The { Latitude ——— 51d. 32m. } North
Sun's Declination 23d. 30m }

In the *Rectangle Spheric Triangle* Akl. *Plate* 7 *Fig.* 2. Obſerve That

1. Akl the Rectangle.
2. kAl the Latitude.
3. kl the Sun's Dec. of the ſame Name with the Lat.
4. A l his Altitude when he is upon the Eaſt or Weſt Azimuth Circle.
5. A k the Hour from 6 ; if Eaſt, after 6 in the Forenoon ; but when Weſt, before 6 Afternoon.

To project it *Sterographically*, on the Plain of the Meridian ;

1. The Primitive Circle being drawn, quartered, as alſo

the Axis PAl, Eqinoctial Æ A Q, and Parallel of Declination ♋ ☉ l f R g, as formerly, in *Problem* 4. of this *Chapter*, to cut the Prime Vertical ZAN in l, the Place of the Sun when he is either Eaſt, or Weſt.

2. Then thro' l draw a Great Circle to cut the Equinoctial ÆAQ in k, at Right Angles by *Problem* 5. *Caſe* 3. *of Spheric Geometry*, in Page 115, as the Oblique Circle Plkl, which forms the Rectangle Spheric Triangle Akl.

For the Hypotenuſe Al, and Leg Ak, the former the Sun's Altitude, the latter the Hour from 6, when he is either Eaſt, or Weſt, are the two things required, and are meaſured by *Problem* 7. *Caſe* 2, *of Spheric Geometry*, in *pages* 117 and 118.

But by *Trigonometry*, having a Leg and its oppoſite Angle given; that is kAl 51d. 32m. the Latitude, and k l, 23d. 30m the Sun's Declination: The Leg A k the Hour from 6, and the Hypotenuſe A l the Sun's Altitude when Eaſt, or Weſt; are found by *Chapter* 5. *Section* 4. *Problem* 4. *Caſes* 10 and 12 of *Spheric Trigonometry*, in *pages* 138 and 139. Thus,

1. To find the Sun's Altitude, the Proportion is;

As the Sine of the Latitude, is to the Radius,

So is the Sine of the Sun's Declination, to the Sine of his Altitude, being Eaſt or Weſt, Or thus;

As S. Angle KAl ·· Radius : : S. Leg k l ·· S. Hypot. A l
As S. 51d. 32m. ·· S. 90d. : : S. 23d. 30m. S 30d. 37m. ☉ *Alt.*

2. To find the Hour from 6, the Proportion by the aforeſaid *Problem* 4. and *Caſe* 10. is;

As the Radius, is to the Tangent of the Complement of the Latitude;

So is the Tangent of the Sun's Declination, to the Sine of the Hour from 6. Or thus,

As Radius ·· Tc. Angle k a l : : T Leg k l ·· S. Leg A k.
As T. 45d. ·· T. 38d, 28m. : : T. 23d. 30m .. S. 20d. 13m, the Hour from Six.

Which reduced into Hours and Minutes of Time, and add it to, and ſubtract it from 6 Hours, giveth the Hour of the Day required.

That is, 20d. 13m. reduced into Time is 1h. 21m. almoſt
Which added to ———————— 6h. 00m.
The Sum ſheweth the Sun is Eaſt at —— 7h. 21m. Morn.
And being ſubtr. ſheweth the Sun is Weſt 4h. 47m. Aftern.

In the ſame Rectangle Spheric Triangle A k l, (*Plate* 7. *Figure* 2.) the five Problems following may be reſolved, to Exerciſe the Learner.

lem 19. *The* Sun's *Eaſt, the* Latitude, *and the* Sun's Alti-
le *given; to find the* Declination, *and the Hour of the* Day.

ple. The { *Latitude* —— 51d. 30m. North.
{ *Sun's Altitude,* 25d. 16m. Morning

:e is the Hypotenuſe, and one Angle given; that is the
tenuſe Al 25d. 16m. the *Sun's Altitude*, and the Angle
1d. 30m. the Latitude; which Triangle is made by
m 11. of *Spheric Trigonometry Geometrical,* in *page* 124;
or its Reſolution, ſee *Chapter* 5. *Section* 4. *Problem* 2.
,, and 5. in *pages* 136, and 137. And is thus.

1. For the *Sun's Declination*, the *Proportion* is.
ius .. S. *Latitude* :: S. ☉ *Altitude* .. S. ☉ *Declina.* Req:
)d. .. S. 15d. 30m. :: S. 25d. 16m. .. S. 19d. 30m. Nor.

2. For the Hour when he is *Eaſt*, it's thus;
:. ☉ *Alt.* .. *Rad.* :: S.c.*Lat.* .. T.*Hour* from 6 when E. Or,
lius .. S c. *Lat.* :: T. ☉ *Alt.* .. T.*Hour* from 6, when E.
)d: .. S.38d.30m.:T.25d. 16m. .. T.16d.20m.or 1h.5m:
1 added to 6 makes 7h. 5m. the time when the *Sun*
t.

em 20. *The* Sun *Weſt, the* Latitude *and Hour of the Day*
en; to find his Altitude, *and* Declination.

ample. The { *Latitude* 30d. 10m. South.
{ *Hour* —— 3h. 15m. P M. or Afternoon

re is given a Leg, and it's adjacent Angle, that is; the
k 41d. 15m. or 2h. 45m. the Hour from 6, when the
Weſt; and the Angle kAl 30d. 10m. the *Latitude*;
1 Triangle is made by *Problem* 12. of *Spheric Trigonometry*
trical. And for its Reſolution, ſee *Chapter* 5. *Section* 4.
3. *Caſe* 7, and 9. In *pages* 137, and 138. And it's thus.

1. For the *Sun's Declination*, the *Proportion* is;
. *Lat.* .. *Radius* :: S *Hour* from 6 .. T. ☉ *Declina.* Or,
lius .. S Hour *from* 6 :: T. *Latitude* .. T. ☉ *Decli.* Req.
90d. .. S. 41d.15m. :: T.30d.10m. .. T.20d. 58m. *South*

2. For his *Altitude*, the *Proportion is,*
*Hour*from6 .. *Radius*::Sc.Lat. .. Tc. ☉ *Alt.* when W. Or,
Lat. .. *Radius* :: T.Hour fr.6 .. T. ☉ *Alt* when W. Req.
9d.50m. .. S.90d ::T.41d.15m. .. T.45d.23m. ☉ *Alt.*
Weſt

em 21. *The* Sun's *Eaſt, his* Declination, *and* Altitude gi-
; *to find the* Latitude, *and Hour of the Day.*

ple. The Sun's { *Declination* 20d. 50m. *South.*
{ *Altitude* 29d. 30m. A.M. or *Morn-*

the Axis PAI, Eqinoctial Æ A Q, and Parallel of Declir ♋ ☉ l f R g, as formerly, in *Problem* 4. of this *Chapte* cut the Prime Vertical ZAN in l, the Place of the Sun he is either Eaſt, or Weſt.

2. Then thro' l draw a Great Circle to cut the Equi ÆAQ in k, at Right Angles by *Problem* 5. *Caſe* 3. *of Geometry*, in Page 115, as the Oblique Circle PlkI, forms the Rectangle Spheric Triangle Akl.

For the Hypotenuſe Al, and Leg Ak, the former the Altitude, the latter the Hour from 6, when he is either or Weſt, are the two things required, and are meaſure *Problem* 7. *Caſe* 2, *of Spheric Geometry*, in *pages* 117 and 11

But by *Trigonometry*, having a Leg and its oppoſite given; that is kAl 51d. 32m. the Latitude, and k l, 30m the Sun's Declination: The Leg A k the Hour fr and the Hypotenuſe A l the Sun's Altitude when Ea Weſt; are found by *Chapter* 5. *Section* 4. *Problem* 4. *Caſes* 1 12 of *Spheric Trigonometry*, in *pages* 138 and 139. Thus,

1. To find the Sun's Altitude, the Proportion is;

As the Sine of the Latitude, is to the Radius,

So is the Sine of the Sun's Declination, to the Sine o Altitude, being Eaſt or Weſt, Or thus;

As S. Angle KAl ·· Radius :: S. Leg k l ·· S. Hypot. A l
As S. 51d. 32m. ·· S. 90d. :: S. 23d. 30m. S 30d. 37m. ☉

2. To find the Hour from 6, the Proportion by the a ſaid *Problem* 4. and *Caſe* 10. is;

As the Radius, is to the Tangent of the Complement o Latitude;

So is the Tangent of the Sun's Declination, to the Sir the Hour from 6. Or thus,

As Radius ·· Tc. Angle k a l :: T Leg k l ·· S. Leg A
As T. 45d. ·· T. 38d, 28m. :: T. 23d. 30m. ·· S. 20d. the Hour from Six.

Which reduced into Hours and Minutes of Time, and it to, and ſubtract it from 6 Hours, giveth the Hour of th required.

That is, 20d. 13m. reduced into Time is 1h. 21m. al
Which added to —————————— 6h. 00m.
The Sum ſheweth the Sun is Eaſt at —— 7h. 21m. M
And being ſubtr. ſheweth the Sun is Weſt 4h. 47m. Aft

In the ſame Rectangle Spheric Triangle A k l, (*Plate gure* 2.) the five Problems following may be reſolved, to erciſe the Learner,

F

Problem 19. *The* Sun's *Eaſt*, *the* Latitude, *and the* Sun's Altitude *given*; *to find the* Declination, *and the Hour of the* Day.

Example. *The* { *Latitude* —— 51d. 30m. North.
{ *Sun's Altitude*, 25d. 16m. Morning

Here is the Hypotenuſe, and one Angle given; that is the Hypotenuſe Al 25d. 16m. the *Sun's Altitude*, and the Angle kAl 51d. 30m. the Latitude; which Triangle is made by *Problem* 11. of *Spheric Trigonometry Geometrical*, in *page* 124; and for its Reſolution, ſee *Chapter* 5. *Section* 4. *Problem* 2. *Caſe* 4, and 5. in *pages* 136, and 137. And is thus.

1. For the *Sun's Declination*, the *Proportion* is.

AsRadius .. S. *Latitude* :: S. ☉ *Altitude* .. S. ☉ *Declina.* Req.
AsS90d. .. S. 15d. 30m. :: S. 25d. 16m. .. S. 19d. 30m. Nor.

2. For the Hour when he is *Eaſt*, it's thus;

AsT.c. ☉ *Alt.* .. *Rad.* :: S.c.*Lat.* .. T.*Hour* from 6 when E. Or,
As*Radius* .. S c. *Lat.* :: T. ☉ *Alt.* .. T.*Hour* from 6, when E.
AsS.90d. .. S.38d.30m.:T.25d. 16m. .. T.16d.20m.or 1h.5m.
which added to 6 makes 7h. 5m. the time when the *Sun* is Eaſt.

Problem 20. *The* Sun *Weſt*, *the* Latitude *and Hour of the Day given*; *to find his* Altitude, *and* Declination.

Example. *The* { *Latitude* 30d. 10m. South.
{ *Hour* —— 3h. 15m. P M. or Afternoon

Here is given a Leg, and it's adjacent Angle, that is; the Leg Ak 41d. 15m. or 2h. 45m. the Hour from 6, when the Sun is *Weſt*; and the Angle kAl 30d. 10m. the *Latitude*; which Triangle is made by *Problem* 12. of *Spheric Trigonometry Geometrical*. And for its Reſolution, ſee *Chapter* 5. *Section* 4. *Prob.* 3. *Caſe* 7, and 9. In *pages* 137, and 138. And it's thus.

1. For the *Sun's Declination*, the *Proportion* is;

AsT.c. *Lat.* .. *Radius* :: S *Hour* from 6 .. T. ☉ *Declina.* Or,
As *Radius* .. S Hour *from* 6 :: T. *Latitude* .. T. ☉ *Decli.* Req.
As S. 90d. .. S. 41d.15m. :: T.30d.10m. .. T.20d. 58m. *South*

2. For his *Altitude*, the *Proportion is*,

AsT.*Hour*from6 .. *Radius*::Sc.Lat. .. Tc. ☉ *Alt.* when W. Or,
As S.c.*Lat.* .. *Radius* :: T.Hour fr.6 .. T. ☉ *Alt* when W. Req.
AsS. 59d.50m. .. S.90d ::T.41d.15m. .. T.45d.23m. ☉ *Alt.* when Weſt

Problem 21. *The* Sun's *Eaſt*, *his* Declination, *and* Altitude *given*; *to find the* Latitude, *and Hour of the Day.*

Example. *The Sun's* { *Declination* 20d. 50m. *South.*
{ *Altitude* 29d. 30m. A.M. or *Morn-*

Here are given the Hypotenuſe, and one Leg; that is, the Hypotenuſe Al, 29d. 30m. the *Sun's Altitude*, and the Leg kl 20d. 50m. his *Declination*: Which Triangle is made by *Problem* 10. of *Spheric Trigonometry Geometrical*, in *page* 122. and for its Reſolution, ſee *Chapter* 5. *Section* 4. *Problem* 1. *Caſe* 2, and 3; in *page* 135, and 136.

Problem 22. *The Sun Weſt, his* Declination, *and Hour of the Day given; to find the* Latitude, *and his* Altitude.

Ex. The { *Sun's Declination* 10d. 39m. *North*,
{ *Hour of the Day* 4h. 52m P. M. (or Afternoon)

Here are given both Legs; that is, the Leg k l 10d. 39m. the *Sun's Declination*, and Leg A k 17d. or 1h. 8m. the *Hour* from 6, when the Sun is Weſt; for making this Triangle, ſee *Problem* 14. of *Spheric Trigonometry Geometrical*, in *page* 127. And for its Reſolution ſee *Chapter* 5. *Section* 4. *Problem* 5. *Caſe* 13, and 14. in *page* 139, and 140.

Problem 23. *The* Sun *Eaſt, his* Altitude, *and the Hour of the Day given; to find the* Latitude, *and his* Declination.

Example. The { *Sun's Altitude* —— 30d. 10m.
{ *Hour of the Day* —— 7h. 50m. A M.

Note; In this Problem the *Latitude* may be either *North* or *South*, and truly anſwer the Queſtion.

Here is given the Hypotenuſe, and one Leg; that is, the Hypotenuſe A l 30d. 10m. the *Sun's Altitude* when Eaſt, and the Leg A k 27d. 30m. or 1h. 50m. the Hour from 6, when he is ſo; this Triangle is made by *Problem* 10. of *Spheric Trigonometry Geometrical*, in *page* 123, and for its Reſolution, ſee *Chapter* 5 *Section* 4. *Problem* 1. *Caſe* 1 and 3. in *page* 135 and 136.

Problem 24. *The* Sun *in the* Equinoctial, *the* Latitude *of a Place, and the* Sun's Altitude *given; to find his* Azimuth, *and the Hour of the Day.*

Note; When the *Sun* hath no Declination, he is then (ſaid to be) in the *Equinoctial*; which is twice in a Year, about the 10th of *March*, and the 12th of *September*.

Example, The { *Latitude* —— 51d. 32m. *North.*
{ *Sun's Altitude* 21d. 50m. A.M. (or *Morning.*)

In the *Rectangle Spheric Triangle* ZÆD, *Plate* 7. *Fig.* 2. it is to be Noted;

1. ZÆD the *Rectangle*
2. ZÆ the Latitude of the Place
3. ÆD the Hour of the Day from Noon
4. ZD the Complement of the Sun's Altitude.
5. ÆZD the Sun's Azimuth from the *South* in *North Latitude*; but from the *North* in *South Latitude*; Eaſterly in the Forenoon, and Weſterly in the Afternoon.

To project it *Stereographically*, by the Plain Scale.

1. The Primitive Circle being drawn, quartered, as alſo the Axis PAI, and Equinoctial ÆAQ, as formerly directed in *Problem* 4.

2. By *Problem* 9, *Caſe* 2. of *Spherical Geometry*, in *page* 121. draw a parallel Circle at 21d. 50m. (the given *Altitude*,) diſtance from the Horizon SAB; as is ADlt, to cut the *Equinoctial* ÆAQ, in D; the place of the Sun at that Time.

3. Through D (by *Problem* 5. *Caſe* 3. of *Spherical Geometry*, in *page* 115.) draw a Great Circle perpendicular to SAB, as is the Oblique Circle ZDCN, which concludes the Rectangle Spheric Triangle ZÆD, and it's done.

For the Angle ÆZD, and Leg ÆD; the former the *Sun's Azimuth* from the Meridian, the latter the Hour from Noon, when the Sun is in the Equinoctial, are the two things Required, and are meaſured by *Problem* 7. *Caſe* 2, and *Problem* 8. *Caſe* 2. of *Spherical Geometry*, in *page* 118, and 119.

But by Spheric Trigonometry, having the *Hypotenuſe*, and one *Leg* given; that is, ZD 78d. 10m. the Complement of the *Sun's Altitude*, and ZÆ 51d. 32m. the Latitude: The Angle ÆZD the Sun's Azimuth and Leg ÆD the Hour from Noon, are found by *Chapter* 5. *Section* 4. *Caſe* 1 and 2. of *Spheric Trigonometry Rectangular*, in *page* 135 and 136. Thus,

1. To find the *Sun's Azimuth*, the Proportion is;
As the Radius is to the Tangent of the Latitude;
So is the Tangent of the Sun's Altitude, to the Sine Complement of the Sun's Azimuth from the South. Or thus;

As *Radius* ·· T. *Leg* ZÆ : : T c. *Hipot.* ZD ·· Sc. Angle ÆZD.
As T. 45d. ·· T. 51d. 32m. : : T. 21d. 50m. ·· S. 30d 17m.
Which ſubtract from ———————— 90d. 00m.
Remainder is the *Sun's Azimuth*, South ——— 59.d 43m.

Eaſterly, That is S E by E. ¼ E. is the point of the Compaſs the Sun is upon

2. To find the Hour, the Proportion by the foreſaid *Problem* 1. and *Caſe* 3. is;

As the Sine Complement of the Latitude, is to the Radius;

So is the Sine of the Sun's Altitude, to the Sine Complement of the Hour from Noon. Or thus;

As S.c *Leg* ZÆ ·· *Radius* : : S.c. *Hypot.* ZD S c. *Leg.* ÆD.
As S. 38d. 28m. ·· S. 90d. : : S 21d. 50m. ·· S. 36d. 43m.
Which ſubtract from ———————— 90d. 00m.
Remainder is the Hour from Noon ——— 53d. 17m.

Which is equal to 3h. 33m. from Noon, that is 8h. 27m. in the *Morning*

In the ſame Rectangle Spheric Triangle ZÆD might five Problems more be reſolved, which I leave the Learner to invent, and ſo paſs on to *Oblique Spheric Triangles* in *Aſtronomy.*

Section III. Oblique Spheric Triangles, *applied im* Aſtronomical Problems, *uſeful in* Navigation.

IN the laſt *Section,* Rectangled Spheric - Triangles was applied to *Problems* of *Aſtronomy,* now in like manner Oblique Spheric Triangles ſhall be applied, and both them and the following are uſeful in *Navigation.*

Problem 1. *The* Latitude *of a Place, the* Sun's Declination, *and his* Altitude *given; to find his* Azimuth, *and the Hour of the Day.*

Example. The
Latitude ——— 51d. 30m.
Declination ——— 15 10
Altitude ——— 11 30
North

In the Oblique Spheric Triangle PZ☉. *Plate* 7. *Figure* 2. is to be Noted.

1. ZP the Complement of the Latitude.
2. Z☉ the Complement of the Sun's Altitude.
3. P☉ his Diſtance from the Elevated Pole; which is the Declination added to 90 Degrees, when the Latitude and Declination are of contrary Names: But if of one Name, its the Complement of the Declination.

4 PZ

PZ⊙ his Azimuth from the North in North Latitude;
from the South in South Latitude.

. ZP⊙ the Hour of the Day from Noon.

To project it *Sterographical*, on the Plain of the Meridian

, Having drawn the Primitive Circle and quarter'd
drawn the Axies PAI, and the Equinoctial ÆAQ, draw
Parallel of Declination ⊙ l f R g,

. Draw (by *Problem* 9. *Caſe* 2. *of Spheric Geometry* in *page*
1) a Parallel Circle, parallel to the *Horizon* SAB, at 11d.
n (the given Altitude) diſtance from it, to cut the paral-
of Declination in ⊙, the place of the Sun at that time.

Then through ⊙ draw two Great Circles, one through
nd N, the Poles of the *Horizon*; and the other through
nd I the Poles of the Equinoctial; as is the *Oblique Circle*,
N, and P⊙I; which forms the *Oblique Spheric Triangle*
⊙, and it's done.

For the Angles PZ⊙, and ZP⊙, the former the Sun's
imuth, the latter the Hour of the Day from Noon; are
Two Things required, and are meaſured by *Problem* 8.
ſe 2 of *Spheric Geometry*, in *page* 119.

But by Spheric Trigonometry, having 3 Sides given; that
P, 38d, 30m. the Complement of the Latitude, Z⊙, 78d.
n. the Complement of the *Sun's Altitude*; and P⊙, 74d.
n. his Diſtance from the Elevated Pole; the Angles PZ⊙
Sun's Azimuth, and ZP⊙ the *Hour of the Day*; are found
Chapter 5. *Section* 5. *Problem* 11. *Caſe* 11. of *Spheric Trigo-
etry Oblique*, in *pages* 147, and 148, as followeth.

Add the Complement of the Latitude, Complement of
Sun's Altitude, and the Sun's Diſtance from the Pole in-
ne Sum.

. From half that Sum ſubtract, for finding the Sun's *Azi-
th*, the *Sun's Diſtance* from the *Pole*: But, for finding the
ur of the Day, ſubtract the Complement of the Sun's Al-
de, noting the half Sum, and the Remainder,

3. Then to find the Sun's Azimuth, it's thus; to the *Com-
nent Arithmetical* of the Sines of the Complement of the
titude, and Complement of the Altitude, add the *Sines* of
foreſaid Half-Sum, and Remainder: half the Total of
ſe 4 Logarithms, is the *Sine* of the *Supplement* of half the
's *Azimuth* from the North in North Latitude; and from
South, in South Latitude.

As *Radius* .. T. *Leg* ZÆ : : T c. *Hipot.* ZD .. Sc. Angle *A*
As T. 45d. .. T. 51d. 32m. : : T. 21d. 50m. .. S. 30d
Which ſubtract from ——————————— 90d.

Remainder is the *Sun's Azimuth*, South ——— 59.d
Eaſterly, That is S E by E. ¼ E. is the point of the C
paſs the Sun is upon

2. To find the Hour, the Proportion by the foreſaid
blem 1. and *Caſe* 3. is;

As the Sine Complement of the Latitude, is to
Radius;

So is the Sine of the Sun's Altitude, to the S
Complement of the Hour from Noon. Or thus;

As S.c *Leg* ZÆ .. Radius : : S.c. *Hypot.* ZD S.c. *Leg*
As S. 38d. 28m. .. S. 90d. : : S 21d. 50m. .. S. 36d.
Which ſubtract from ——————————— 90d.

Remainder is the Hour from Noon ——— 53d.
Which is equal to 3h. 33m. from Noon, that is 8h. 27
the *Morning*.

In the ſame Rectangle Spheric Triangle ZÆD might
Problems more be reſolved, which I leave the Learner to
vent, and ſo paſs on to *Oblique Spheric Triangles* in *Aſtrono*

Section III. Oblique Spheric Triangles, *applied im* A nomical Problems, *uſeful in* Navigation.

IN the laſt *Section*, Rectangled Spheric - Triangles applied to *Problems* of *Aſtronomy*, now in like manner lique Spheric Triangles ſhall be applied, and both them the following are uſeful in *Navigation*.

Problem 1. *The* Latitude *of a Place, the* Sun's Declina *and his* Altitude *given; to find his* Azimuth, *and the Ho the Day.*

Example. The { *Latitude* —— 51d. 30m. } North
{ *Declination* —— 15 10 }
{ *Altitude* —— 11 30 }

In the Oblique Spheric Triangle PZ☉. *Plate* 7. *Figu* is to be Noted.

1. ZP the Complement of the Latitude.
2. Z☉ the Complement of the Sun's Altitude.
3. P☉ his Diſtance from the Elevated Pole; which i Declination added to 90 Degrees, when the Latitude Declination are of contrary Names: But if of one Nam the Complement of the Declination.

4. PZ⊙ his Azimuth from the North in North Latitude; but from the South in South Latitude.

5. ZP⊙ the Hour of the Day from Noon.

To project it *Sterographical*, on the Plain of the Meridian

1. Having drawn the Primitive Circle and quarter'd alſo drawn the Axies PAI, and the Equinoctial ÆAQ, draw the Parallel of Declination ⊙ l f R g,

2. Draw (by *Problem* 9. *Caſe* 2. *of Spheric Geometry* in *page* 121) a Parallel Circle, parallel to the *Horizon* SAB, at 11d. 30m (the given Altitude) diſtance from ~~it~~, to cut the parallel of Declination in ⊙, the place of the Sun at that time.

3 Then through ⊙ draw two Great Circles, one through Z and N, the Poles of the *Horizon*; and the other through P and I the Poles of the Equinoctial; as is the *Oblique Circle*, Z⊙N, and P⊙I; which forms the *Oblique Spheric Triangle* PZ⊙, and it's done.

For the Angles PZ⊙, and ZP⊙, the former the Sun's Azimuth, the latter the Hour of the Day from Noon; are the Two Things required, and are meaſured by *Problem* 8. *Caſe* 2 of *Spheric Geometry*, in *page* 119.

But by Spheric Trigonometry, having 3 Sides given; that is ZP, 38d. 30m. the Complement of the Latitude, Z⊙, 78d. 30m. the Complement of the *Sun's Altitude*; and P⊙, 74d. 50m. his Diſtance from the Elevated Pole; the Angles PZ⊙ the *Sun's Azimuth*, and ZP⊙ the *Hour of the Day*; are found by *Chapter* 5. *Section* 5. *Problem* 11. *Caſe* 11. of *Spheric Trigonometry Oblique*, in *pages* 147, and 148, as followeth.

1 Add the Complement of the Latitude, Complement of the *Sun's* Altitude, and the Sun's Diſtance from the Pole into one Sum.

2. From half that Sum ſubtract, for finding the Sun's *Azimuth*, the *Sun's Diſtance* from the *Pole*: But, for finding the Hour of the Day, ſubtract the Complement of the Sun's Altitude, noting the half Sum, and the Remainder.

3. Then to find the Sun's Azimuth, it's thus; to the *Complement Arithmetical* of the Sines of the Complement of the Latitude, and Complement of the Altitude, add the *Sines* of the foreſaid Half-Sum, and Remainder: half the Total of theſe 4 Logarithms, is the *Sine* of the *Supplement* of half the *Sun's Azimuth* from the North in North Latitude; and from the South, in South Latitude.

But to find the Hour of the Day, it's thus; to the *Complement Arithmetical* of the Sines of the Complement of the Latitude, and the Sun's Diſtance from the Pole, add the Sines of the ſaid Half-Sum, and the Remainder: Half the Total of theſe 4 Logarithms, is the Sine of the Supplement of half the Hour from Noon, all which is ſhortned thus;

1. To find the Azimuth, the Operation is;

Side ZP 38. 30m.	Containing Sides S, *co. ar.* 0 205850
Z☉ 78 30m.	S. *co. ar.* 0.008107
P☉ 74d. 50m	half ſum ſides 95d. 55m S 9.997680
Sum is 191d 50m.	Remainder 21d. 05m. S, 9.555971
½ Sum is 95d. 55m	Sum of the 4 Logarithms is 19.768308
Remaind 21d. 05m.	—— 49 59 S½ ſum-9.884154

Which doubled—49 59

The double is —— 99 58 Which

ſubtract from —— 180 00

Remainder the is Sun's Azimuth 80 02 from the North

Or thus, by Gunter's Scale

As the *Radius* .. S c. *Latitude*, : : S c. *Altitude* .. a 4th Sine

As S. 90d. .. S. 38d 30m. : : S 78d. 30m. .. S 37d. 35m.

Then again,

As the 4th *Sine* .. S½*Sum ſides* : : S. *Remainder* .. a 5th Sine

As S 37d. 35m. .. S. 95d. 55m : : S. 21d. 05m. .. S. 36d. 06m.

Againſt which, on the Line of Verſed Sines is 80d 02m. the Sun's Azimuth from the North Eaſterly, if in the Morning, and from the North Weſterly if in the Afternoon; that is, the Sun is near the E. by N. Point of the Compaſs in the Morning and near the W by N. Point in the Afternoon.

2. To find the Hour of the Day, the Operation is,

Side { ZP 38d.30m. } Containing Sides { S. *co. ar.*--0.205850
⊙P 74d.50m. } S. *co. ar.*--0.015397
Z⊙ 78d.30m | half Sum ſides 95d. 55m.S— 9.997680
Sum is 191d. 50m. | Remainder 17d. 25m.S.—9.476133
$\frac{1}{2}$ Sum is 95d. 55m | Sum of the 4 Logarithms is 19.695060
Remaind. 17d. 25m. | —— —— 44.45 S. half Sum 9.847530
Which doubled —— 44.45
The double is —— 89.30 Which
ſubtract from —— 180.00 h. m.
Rem: is the Hour from Noon: 90,30 equal to 6 02

Or thus ; by Gunter's Scale.

As the *Radius* .. S.c.*Latitude*, : : S. ⊙ *Diſt. from Pole* .. a 4th Sine
As S. 90d. .. S.38d.30m. : : S. 74d.50m. .. S. 36d. 56m,
Then again,
As the 4th *Sine* .. S$\frac{1}{2}$*Sum ſides* : : S. Remainder .. a 5th Sine.
As S.36d.56m .. S.95d.55m : : S. 17d. 25m. .. S.29d. 42m.

Againſt which on the line of Verſed Sines, is 90d. 30m. Or 6h. 2m. the Hour from Noon ; that is, 58m. after 5 in the Morning. or 2m. after 6 in the Afternoon

In the ſame Spheric Triangle ZP⊙, (*Plate* 7. *Fig*, 2.) may the Nine Problems next following be reſolved.

Problem 2. *The* Latitude *of a Place, the Sun's* Altitude, *and* Azimuth *given; to find his* Declination, *and the Hour of the Day.*

Example. *The* { Latitude —— 51d. 32m. North
Sun's Altitude 49d. 40m. in the Forenoon
Sun's Azimuth 119d. 44m. from the North

In this Problem are two Sides, and one Angle between them given ; that is, ZP 38d. 28m. the Complement of the *Latitude*, Z⊙ 40d. 20m. the Complement of the *Sun's Altitude*, and PZ⊙ 119d. 44m. his Azimuth ; which Triangle is made by *Problem* 18. of *Spheric Geometry* ; and for its Reſolution, ſee *Chapter* 5. *Section* 5. *Problem* 9. *Caſe* 7, and 8. of *Spherical Trigonometry Oblique*, in *page* 144 and 145.

Problem 3, *The* Latitude, *the* Sun's Declination, *and* Azimuth *given ; to find his* Altitude, *and the Hour of the Day.*

Ex. The { Latitude —— 13d. 10m. North
⊙Declination – 9d. 15m. South
⊙ Azimuth —— 129. 40m. from N. Afternoon.

Here are two Sides, and one Angle oppoſite given, that is ZP 76d. 50m the Complement of theLatitude, P⊙ 99d. 15m. the Sun's Diſtance from the Elevated Pole, and PZ⊙ 129d 40m. his Azimuth; which Triangle is made by *Problem 16.* of *Spheric Geometry*, in *page* 128 *and* 129. And for its ſolving, ſee *Chapter* 5. *Section* 5. *Problem* 7. *Caſe* 2, *and* 3. of *Spheric Trigonometry Oblique*, in *page* 142 and 143.

Problem 4. *The* Latitude *of a* Place, Sun's Altitude, *and the Hour of the Day given; to find the* Sun's Azimuth, *and his* Declination.

Example. The
Latitude——30d. 51m. *South*
Altitude —— 41d. 10m.
Hour of the Day 3h. 15m. *Afternoon.*

Here are two Sides, and one Angle oppoſite given as before in *Problem* 3. That is, ZP 59d. 09m. the Complement of the Latitude, Z⊙ 48d. 50m. the Complement of the *Sun's Altitude*, and ZP⊙ 48d. 45m. Or 3h. 15m. the Hour of the Day from Noon; and therefore projected, and reſolved like *Problem* 3. aforeſaid, in *page* 231.

Problem 5. *The* Latitude *of a* Place, *the* Sun's Declination, *and Hour of the Day given; to find his* Azimuth, *and* Altitude.

Example. The
Latitude —— 20d. 11m. *North.*
Declination— 23d. 29m. *South.*
Hour —— 9h. 24m. *Morning.*

Here are two Sides, and one Angle between them given; That is, ZP 69d. 49m. the Complement of the Latitude, P⊙ 113d. 29m. the *Sun's Diſtance* from the Elevated *Pole*, and PZ⊙, 39d. or 2h. 36m. the Hour of the Day from Noon, which is wrought as before in *Problem* 2. *page* 231.

Problem 6. Latitude *of a* Place, *the* Sun's Azimuth, *and the Hour of the Day given; to find the* Sun's Declination *and* Altitude

Example. The
Latitude ——— 13d. 10m. *North*
Sun's Azimuth —120d. 30m. *from the North*
Hour of the Day--- 9h. 36m. *Morning*

Here are two Angles, and one Side between them given. That is ZP 76d. 50m. the Complement of the *Latitude*, PZ⊙ 120d. 30m. the *Sun's Azimuth*, and ZP⊙ 36d. or 2h. 24m. the Hour of the Day from Noon; for the making of this Triangle, ſee *Problem* 19. of *Spheric Geometry*, in *page* 130. And for its Solution, ſee *Chapter* 5. *Section* 5. *Problem.* 10. *Caſe* 9. of *Spheric Trigonometry Oblique, in page* 146.

Problem 7. *The* Sun's Altitude, Declination, *and his* Azimuth *given, to find the* Latitude *and Hour of the Day.*

Example. *The* Sun's
Altitude 39d.30m. in the Morning,
Declination 19d.12m. North.
Azimuth 110d. 20m. from the North

Here are two Sides, and one Angle oppoſite given; That is, Z⊙ 50d. 30m the Complement of the Sun's Altitude, P⊙ 70d. 48m. his Diſtance from the Elevated Pole, and PZ⊙ 110d. 20m. his Azimuth from the North, which Triangle is made and wrought as before in *Prob.* 3. of this *Sect.* in *page* 232.

Problem 8. *The* Sun's Altitude, *his* Declination, *and Hour of the Day given; to find his* Azimuth, *and the* Latitude.

Example. The
Sun's Altitude —— 12d. 35m.
Sun's Declination -- 19d. 40m. North.
Hour ——— —— 5h. 42m. Morning

Here are alſo two Sides, and one Angle oppoſite given; That is, Z⊙ 58d. 35m. the Complement of the *Sun's Altitude* P⊙ 70d. 20m. his Diſtance from the Elevated Pole, and ZP⊙ 94d. 30m. or 6h. 18m. the Hour of the Day from Noon; which Triangle is made and wrought as before in *Problem* 3. of this *Section*, in *page* 232.

Problem 9. *The* Sun's Altitude, *his* Azimuth, *and the Hour of the Day given; to find the* Declination, *and the* Latitude *of the Place.*

Example. *The*
Sun's Altitude ——— 11d. 30m.
Sun's Azimuth —— 75d. 00m. from the N.
Hour of the Day --- 06h. 16m. Afternoon

Here are two Angles and one Side oppoſite given; That is Z⊙ 70d. 30m. the Complement of the Sun's Altitude, PZ⊙ 75d. The Sun's Azimuth from the North, and ZP⊙ 94d. 00m. or 6h. 16m. the Hour from Noon; which Triangle is made by *Problem* 17. *of Spheric Geometry*, and is ſolved by *Chapter* 5. *Section* 5. *Prob.* 8. *Caſe* 4 *and* 5, *of Spheric Trigonometry Oblique*, in *page* 143, *and* 144.

Problem 10. *The* Sun's Declination, *his* Azimuth, *and Hour of the Day given; to find his* Altitude, *and the* Latitude *of the* Place.

Example. *The* Sun's Declination —— 19d, 10m. North
Sun's Azimuth —— 79d. 02m. from the S.
Hour of the Day —— 08h. 32m. in Morn.

Here are two Angles and one ſide oppoſite given; as before in the laſt *Problem*: That is, P☉ 70d. 50m. the Sun's Diſtance from the Elevated Pole, PZ☉ 109d.58m. his Azimuth from the North, and ZP☉ 52d. Or 3h. 28m. the Hour of the Day from Noon; which Triangle is made and wrought like *Problem* 9. the laſt foregoing.

Problem 11. *The* Latitude *and* Longitude *of a* Star, *and the* Obliquity *of the* Ecliptic *given; to find his* Right Aſcenſion, *and* Declination.

Definition 1. Latitude of a Star, is an Arch of a Circle of Longitude, contained between the Star's Center and the Ecliptic.

2. Longitude of a Star, is an Arch of the Ecliptic, contained between the beginning of *Aries*, and that Circle of Longitude which paſſeth over the Star's Center, and counted according to the Succeſſion of the Signs.

Example.

Capella, or the *Goat*, the Latitude —— 22d. 52m. North
Longitude ♊ 18d. 02m.

In the Oblique Spheric Triangle PKD, *Plate* 7. *Figure* 1. is to be Noted.

1. PK the Diſtance of the Pole of the Ecliptic from the Pole of the World, equal to the Ecliptic's Obliquity 23d. 30m.

2. KD the Star's Complement of Latitude, or Diſtance from one Pole of the Ecliptic.

3. PD the Complement of the Star's Declination, or Diſtance from the agreeing Pole of the World.

4. PKD it's Longitude from ♋, if the Star's Latitude be North, but from ♑ if it be South; That is, from ♋, if the Ecliptic's North Pole be one Angle; but from ♑ if it's South Pole be one Angle of the Triangle.

5. KPD the Star's Right Aſcenſion from ♑, if its Latitude be North, but from ♋, if its Latitude be South: That is, if the Ecliptic's North Pole be one Angle, *&c.* as before in the 4th *Step.*

Here are two ſides, and one Angle between them given; That is, PK 23d. 30m. the Diſtance of the North Poles of the Equinoctial and Ecliptic, KD 67d. 08m. the Complement of the Star's Latitude, and PKD 11d. 58m. the Star's Longitude from (wanting of) ♋; which Triangle is made by *Problem* 18. *of Spherical Geomety*, in *page* 129, and 130. And by *Chapter* 5. *Section* 5. *Problem* 9. *Caſe* 7, *and* 8. *in pages* 144, *and* 145. the Proportions are as follow.

Firſt, To find the Star's Right Aſcenſion, the *Operation* is

1. As S. half Sum of the Sides KD and KP. —— 45d.19m.
Is to S. half their Difference —— —— 21d.50m.
So is T. c. of half the Angle PKD —— —— 84d.01m.
To T. half Diff. of the Angles DPK and PDK 78d.40m.

2. As S.c. half Sum of the ſides KD and KP —— 44d.41m.
Is to S c. half Difference —— —— —— 68d.10m.
So is Tc. of half the Angle PKD —— —— 84d.01m.
To T. half Sum of the Angles DPK and PDK. 85d.27m.
Unto which add their half Diff. before found —— 78d.40m.
And it giveth the Angle DPK —— —— 164d.07m.
From which ſubtract AQ —— —— —— 90d.00m.
Remainder is AM the Star's Right Aſcenſion -- 74d.07m.
from the beginning of ♈ required.

Secondly, For the Star's Declination, the *Operation* is;

As S. DPK Star's Right Aſcenſion from ♑ —— 164d.07m.
Is to S. DK its Complement of Latitude —— 67d.08m.
So is S. PKD its Longitude from ♋ —— —— 11d.58m.
To S. PD its Complement of Declination —— 44d.19m.
Wherefore the Star's Declination is North —— 45d 41m.

Problem 12. *The Right Aſcenſion of the Sun, and Right Aſcenſion of a Star given; to find the time of the Star's coming to, or upon the Meridian.*

The Rule. Subtract the Sun's Right Aſcenſion from the Star's Right Aſcenſion, the Remainder reduced into Time, is the Time of the Star's coming upon, or to the Meridian, Afternoon.

Note; If you cannot ſubtract, add 360 Degrees to the Star's Right Aſcenſion, and then ſubtract.

Example. *The 5th of* October, 1731; *I demand at what time* Aldebaran, *or the* Bull's Eye, *cometh to the Meridian?*

The

		d.	m.	
The	5th *of* October, *the Sun's Declination* is	8	53	S. *increaſe.*
	Latitude *of* Aldebaran is ——	5	30	South
	Longitude *of* Aldebaran is ——	5	57	in ♊

And therefore you may find that,

			d.	m.
By *Sect.*	3. *Problem* 11.	the *Star's* *Right Aſc. is*	65	03
	2. *Problem* 3.	the *Sun's* *Right Aſc. is*	200	45

Then add 360d. to 65d. 03m. the Star's Right Aſcenſion, and it is 425d. 03m. from which ſubtract 200d. 45m. the Sun's Right Aſcenſion, the Remainder is 224d. 18m. which maketh 14h. 57m. the Star's coming to the Meridian after Noon, that is 57m. after Two in the Morning.

And thus having found the *Right Aſcenſion*, *Declination* and Time of any Star's Coming upon the Meridian, you may by *Problem* 4. *Section* 2. of this *Chapter*, find its Amplitude, and Aſcenſional Difference, and thereby its Riſing and Setting; its Diſtance from the Meridian at any Altitude, obſerved by *Problem* 1. *Section* 3. of this *Chapter*, in *page* 229. and ſo the Hour of the Night thereby; all which I leave for the Exerciſe of thoſe that art learning theſe Things.

Section IV. *The Doctrine of the* Sphere, *or* Spheric Trigonometry, *applied in ſundry* Aſtronomical Problems, *uſeful in* Navigation, *according to the* Pythagorean Syſtem.

THE *Pythagorean Syſtem of the World*, lately revived by *Copernicus*, is now generally received by the moſt, and beſt Aſtronomers; it being indeed the moſt agreeable to the Motion of the *Heavenly Bodies*, confirmed by Experience in the conſtant Obſervation of them, in which theſe are *Fundamental Principles.*

1. That the Earth is carried round the Sun in a large Orb or Path, betwixt the Orbs of the Planets *Mars* and *Venus*, once in a Year.

2. That beſides this *Annual Motion*, the Earth turns round her own Axis once in 24 Hours.

3. And that the ſaid Axis of the Earth, is inclined to the Plane of her Orb at the ſame angle, and keeps in all parts of it, nearly Parallel to it ſelf.

On theſe Aſſertions, but chiefly the Second; to wit, the *Diurnal Motion of the Earth about its own Axis* once in 24 Hours, whereby all the viſible Appearances of the Sun, and

Plate: 7.
Fig: II.

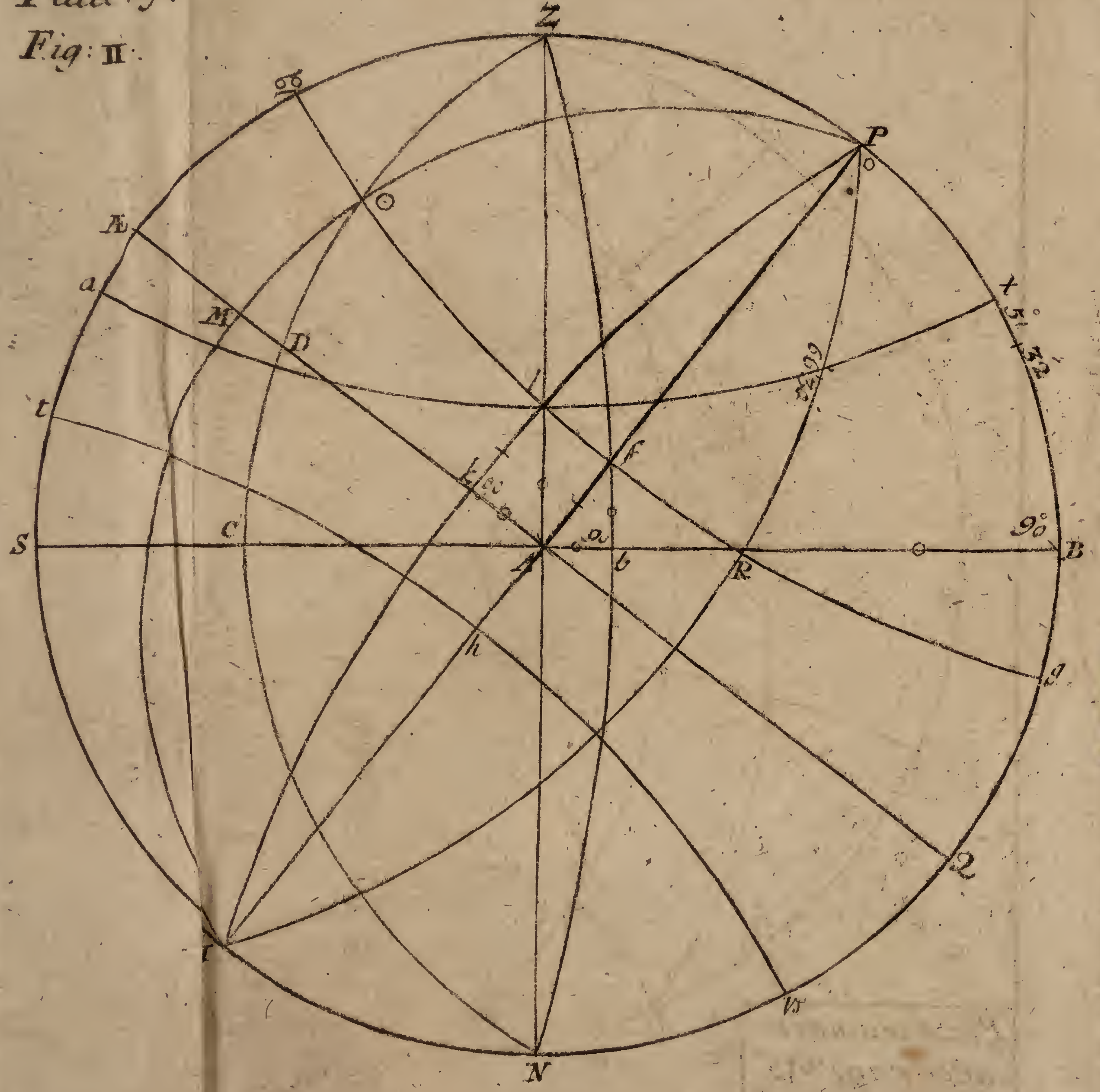
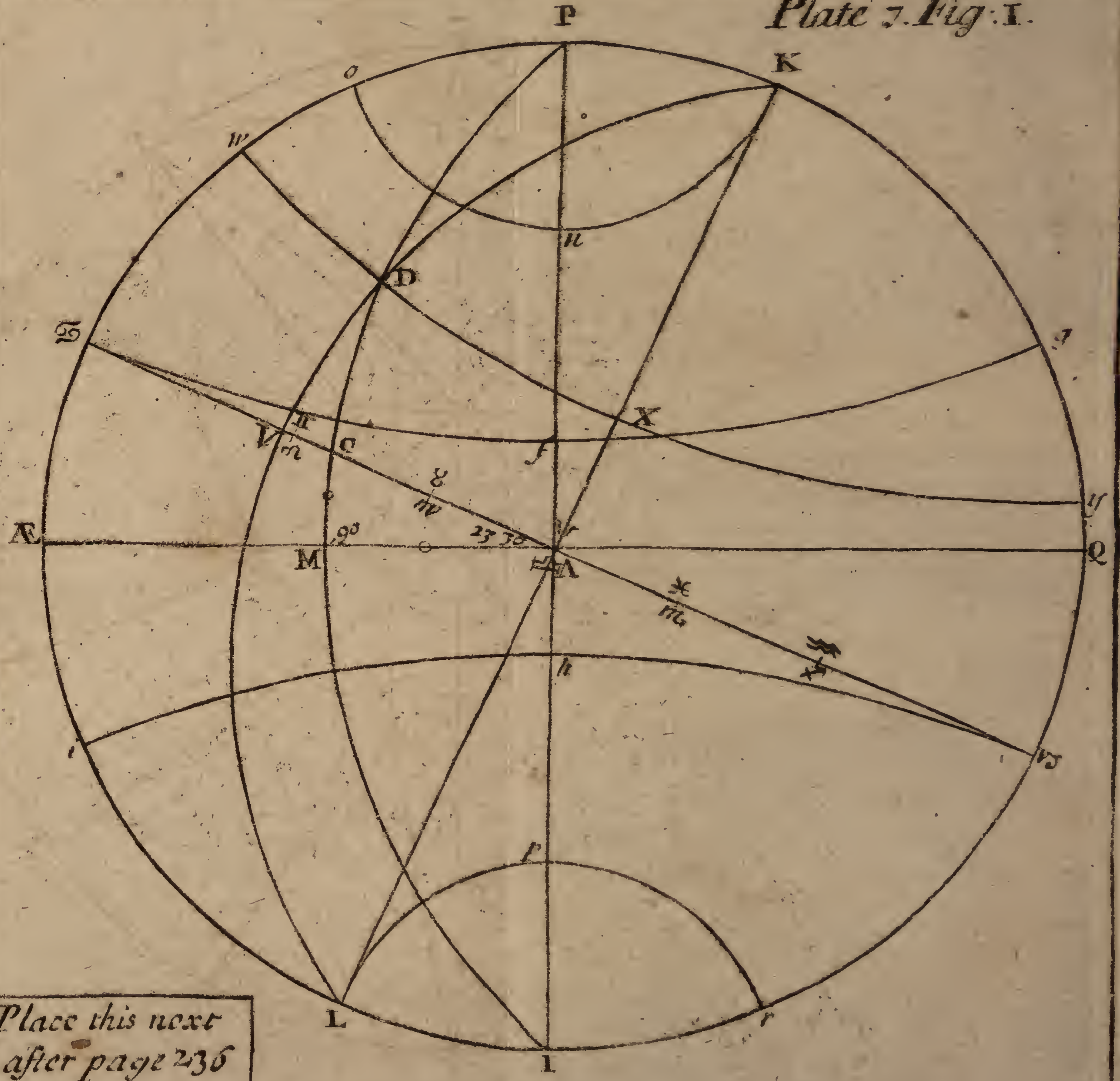


Plate 7. Fig: I.



Place this next
after page 236

FixedStars are ſolved, I ſhall at preſent confine my Diſcourſe, and on which the following Problems are grounded.

In order to a right underſtanding thereof, I will deſcribe the Circles of the Sphere, and how they are drawn in the *Sterographical Projection*, on the Plane of the *Earth's Ecliptic*, before I ſhew how to calculate any of its Requiſites.

Note, In the following Deſcription. I make uſe (for the moſt part) of the ſame Letters for the ſame things, as before in the *Ptolomaic Projection*, treated of in this *Chapter*

The Deſcription of the Circles of the Sphere (*as grounded on the antient* Pythagorean, *or* Copernican Syſtem *of the World, are as followeth.*

1. The Sun illuminateth one half of the Body of the Earth continually; as repreſented by *Plate* 8. *Figure* 1, and 2. wherein the Lines HKS, or HLS, which determineth the *illuminate Part* of the *Earth's Diske* A ⊙ S, from the obſcure HDS; the ſaid HKS, or HLS, is called the Horizon of the *Earth's Diske.*

2. The Primitive Circle ♈♋♎♑♈, is the Earth's Ecliptic; which ever lieth in the Plane of the Ecliptick in the Heavens.

The Poles of the Ecliptic are K and L; the firſt is the North Pole of the Ecliptic, on the Earth's Globe, and the latter the South Pole thereof.

The Poles of the Earth's Globe are P and I; the firſt its North and the latter its South Pole; each being 23d. 30m. from its correſpondent Pole of the Ecliptic; that is KP, equal to LI, is equal to 23d. 30m. on the Scale of *Half-Tangents*, and its called the Line of Direction of the Earth's Axis.

3. The Equinoctial in the Heavens, or Equator on the Earth, is repreſented by the Oblique Circles ♈ Q ♎, or ♈ Æ ♎, of which P and I are the Poles; and they are drawn with the *Secant* of 23d. 30m. according to *Problem* 2. *Caſe* 2. *of Spherical Geometry, in page* 112, and 113

4, All Meridians paſs through the Poles of the Earth's Globe; as here ♈P♎, or ♈I♎, are Meridians, and drawn with the *Secant* of 66d. 30m. the Complement of 23d. 30m. as before.

♈ P ♎, or ♈ I♎, is called the Firſt Meridian; and the Meridian ♋PK♑, or ♋LI♑ is the Earth's *Solſtitial Colure*: for whenever the direct Rays of the Sun run Parallel to this Meridian, and that is, when the Sun appears from the Earth, to be either in ♋ and ♑; then the *Longeſt* or *Shorteſt Days* are made in all Places on the Globe of the Earth.

The Earth's Equinoctial Colure, is ♈K♎, or ♈L♎, for whenever the Central Rays of the Sun run parallel to it, the Days and Nights are equal in all places. Or according to the *Ptolomaick Syſtem*, the Meridian ♈ P ♎; and ♈ I ♎, is the Equinoctial Colure, tho' here we call it the firſt Meridian.

5. Circles of Longitude, paſs thro' the Poles of the Ecliptic, and in this Projection, are Right Circles; therefore are ſtrait Lines; as ♈K♎, ♋K♑, ☉KD, *&c.*

Wherefore the Point in the Earth's Periphery, oppoſite to the Sun, or to a Star, or lying in a ſtrait Line produced from K, or L, thro' the Center of the Sun, or any Star, is called the Sun's or Star's place in the Ecliptic.

Theſe are the Great Circles belonging to this *Projection.* Now followeth,

The Deſcription of the Parallels or Leſſer Circles.

6. Parallels of Declination, are here Parallels to an Oblique Circle; the Equinoctial ♈Q♎, and ♈Æ♎, being ſuch.

The Tropic's are two Parallels of Declination, diſtant from the Equinoctial 23d. 30m. or 66d. 30m. from each Pole of the World; as ♋f g f♋, and ♑ h i h ♑; the firſt is the Tropic of Cancer, the latter is the Tropic of Capricorn.

Theſe Tropic's are thus drawn; from the *Scale of Half Tangents* lay on the *Solſtitial Colure* 47d. (the double of 23d. 30m. from ♑ to g, or from ♋ to i. Or thus; lay the *Half Tangent* of 43d. (the Complement of 47d.) from K to g., or from L to i: Then the middle between ♋ and g; or between ♑ and i, is the Center of theſe Tropics.

The Polar Circles, are two Parallels of Declination, diſtant from the Equinoctial 66d. 30m. or 23d. 30m. from each Pole of the World: as K n o n K, and L p r p L; the firſt is the Artic, the other the Antartic Circle.

They are thus drawn, on the *Solſtitial Cloure*, lay the *Half Tangent* of 47d. (the double of 23d. 30m.) from K to o, or from L to r; then the middle between K and o, or between L and r, is the Center of thoſe Polar Circles.

7. Parallels of Latitude, with reſpect to the Heavens, are in this *Projection* parallel to the *Primitive Circle* which here is the Ecliptic: as any Circle drawn on K or L; as a Center is a Parallel of Latitude.

All theſe Circles are General, as belonging to this *Projec-*

tion, without any regard to the Latitude of any particular Place, on the Globe of the Earth: The Deſcription of the Meridians, or Hour Circles, Azimuths and Parallels of Latitude; alſo how to draw them (theſe being peculiar to a particular Latitude) you ſhall have in their proper place, as they come in uſe in the following Problems.

Problem I. *The Sun's place in the Ecliptic given; to find his Diſtance from the North or South Pole of the Globe; his Right Aſcenſion; and the Angle which the Meridian paſſing through it, makes with the Ecliptic.*

Example. *The Sun's place being in the beginning of* ♊, *or* 60 *Degrees from the firſt Point of* ♈; *I demand his Diſtance from the Pole, &c.*

1. To do this, lay the Sun's Longitude from ♈ 60d. on the Primitive Circle, from ♈ to ☉.

2. Through ☉ and P, or ☉ and I, draw a great Circle ☉ P D, or ☉ I D, which is the proper Meridian, to the Place of the Sun.

3. Then, between the proper Meridian, the Ecliptic, and the Solſtitial Colure, there is formed a Rectangle Spheric Triangle, having its Legs given; to find the Hypotenuſe, and two Angles: That is,

In the Rectangle Spheric Triangle P ♋ ☉, or I♋☉, *Plate* 8. *Figure* 1 and 2.

1. The Leg ♋ ☉, is the Complement of the Sun's Longitude from ♈, or his Diſtance from the Equinoctial, 30d.

2. The Leg ♋ P, or ♋ I, the Diſtance of the Pole of the Globe from the Ecliptic; or the Complement of the Diſtance of the Poles of the Globe and the Ecliptic 66d. 30m.

3. The Hypotenuſe P☉, or I☉, the Sun's Diſtance from the North, or South Pole of the Globe.

4. The Angle ♋P☉, or ♋I☉, the Complement of the Sun's Right Aſcenſion, from the neareſt Equinoctial Point:

5. The Angle P ☉ ♋, or I☉♋, the Angle of the proper Meridian with the Ecliptic.

1. For the Sun's Diſtance from the Pole, the *Proportion* by *Chapter* 5. *Section* 4. *Problem* 5. *Caſe* 14. *of Spherical Trigonometry Rectangular, in page* 139 *and* 140. *is thus*

AsRadius .. S.c.Leg:♋☉::S.c.Leg♋P .. Sc. Hypotenuſe P☉.
As S.90d... S 60 deg. :: S. 23d. 30m. .. S. 20d. 12m. the *Reflection.* That is,

As the Radius, is to the Sine of *Sun's Longitude* from the Equinoctial.

So is the Sine of the two *Poles Diſtance*, to the Sine Complement of his *Diſtance* from the neareſt *Pole* of the Globe; or to the Sine of PB, or IB the Reflection, which is equal to the *Sun's Declination* in the *Ptolomaic Syſtem*: In this Caſe 20d. 12m. North.

2. For the *Sun's Right Aſcenſion*, the *Proportion* is;

As Radius .. S. Leg P♋ : : Tc.Leg ☉♋ .. Tc. Angle ♋P☉.
As S. 90d. .. S. 66d. 30m : : T. 60d. .. T. 57d, 49m. ☉ *Right Aſcenſion* That is,

As the Radius, is to the Sine Complement of the two *Poles Diſtance*;

So is the Tangent of the Sun's Longitude from the neareſt Equinox, to the Tangent of his Right Aſcenſion from the ſaid Equinox.

3. For the Angle of the proper Meridian with the Ecliptic, the Proportion is thus;

As Radius .. S. Leg ♋☉ :: T.c.Leg ♋P .. T.c. Angle P☉♋
As S. 90d. .. S. 30d. :: T. 23d 30m. .. T. 12d. 16m.
Which ſubtract from ———— 90d. 00m.

The Remainder being ———— 77d. 44m. is the Angle of the Meridian and the Ecliptic.

In the ſame Triangle may *Problem* 2, *and* 3. *of Section* 2. of this *Chapter* be reſolved, which I paſs over.

Problem 2. *The Latitude of a Place on the Globe of the Earth, and the Sun's Place in the Ecliptic given; to find his Amplitude, and Aſcenſional Difference, and conſequently his Riſing and Setting.*

Ex. The { *Latitude* —— 51d. 32m. N } *given Sun's* { *Amp. and*
{ *Sun's Place* 00d. 00m. in ♊ } { *Aſcen. Diff.*
Required. *Plate* 8. *Figure* 1 *and* 2.

1. To do this, after you have done what was directed in *Problem* 1. then get the Sum, and Difference of the Latitude's Complement, and the Diſtance of the two *Poles*; that is, the Sum, and Difference of 38d. 28m. and 23d. 30m. the firſt is 61d. 58m. and the latter is 14d. 58m.

2. Then make K t, or Lt, equal to the Half Tangent of 61d. 58m. and alſo K m, or L m, equal to 14d. 58m. on the ſame Scale.

3. The middle between m and t, is the Center of the Circle a b c z t d e h m, which is the Parallel of Latitude for 51d, 32m. and in this Projection, its the Line deſcribed by *London*, as the Earth turns round, and from thence is called the *Path of the Vertex*.

And if you conceive the *Colures*, all the *Meridians*, the *Path* of any *Vertex*, and indeed all the Lines and Circle that are or ſhall hereafter be deſcribed as a *fixed Rete*, cloſe inveſting the *Earth*, whilſt ſhe turns round within it, whoſe Motion about its *Axis* being from *Weſt* to *Eaſt*, then the Sun is ſaid to *Riſe*, when the *Vertex* paſſeth that Point in the *Path* where it cuts the *Horizon* of the *Earth*'s *Diske*, which is here at *a*; To *Culminate* or on the *Meridian* where it croſſeth the proper *Meridian* betwixt him and the *Pole*, which here is at z; and to *Set* where the *Vertex* paſſeth the other Interſection of the *Path* and *Horizon*, as here at h.

4. Thro' *a*, and ☉, draw a great Circle, as olſo thro' *a* and P, ſo have you two *Triangles*, on the *Eaſt-ſide* of the *Meridian*; to wit, ☉ P*a*, and PB*a*; in like manner if you draw Great Circles thro' P, and h; and thro' ☉, and h; they will form two Triangles on the Weſt, or deſcending Side of the *Meridian*: But any one of theſe four Triangles may ſerve to anſwer the *Problem*, and therefore I take one *Triangle* at *Sun Riſing*, which may ſuffice for *Setting*; wherein obſerve.

In the Right-angled Triangle PB*a*, *Plate* 8. *Figure* 1.

1. The *Leg* PB the Reflection or that which is equal to the *Sun's Declination*, found by *Problem* 1. *in page* 239. to be 20d. 12m. *North*.

2. The *Hypotenuſe Pa*, the *Complement of the Latitude of the Place*, or the Diſtance of the *Pole* from the *Vertex*, in this Example 38d. 28m.

3. The Angle B*a*P the *Amplitude*, or the Complement of the *Sun's Azimuth*, from the *North* in *North Latitude*; and from the *South*, in *South Latitude*; for the Angle P*a* ☉ is the *Azimuth* from the *North* at *Sun Riſing*, and the Angle B*a*P is its *Complement*, and therefore equal to the *Amplitude*.

4. The *Angle* BP*a*, the Hour from *Midnight*; that is, the time of his *Riſing* after, and *Setting* before 12 at Night.

1. For the *Angle* B*a*P, the *Sun's Amplitude*; the Proportion by *Chapter* 5, *Section* 4. *Problem* 1. *Caſe* 2. *in page* 135, *and* 136, is thus;

As the S. *Hypotenuſe* P*a* ·· *Radius* : : S. *Leg* BP ·· S. *Angle* B*a*P.
As the S. 38d. 28m. ·· S. 90d. :: S. 20d. 12m. ·· S. 33d. 43m.
That is,

As the Sine Complement of the *Latitude* is to the *Radius*; So is the Sine of the *Reflection*, to the Sine of the *Sun's Amplitude*; 33d. 43m. from the *Eaſt Northerly*, at *Sun Riſing*; and from the *Weſt Northerly*, at *Sun Setting*.

2. For the Angle BP*a*, the Complement of the Aſcenſional Difference, the Proportion by the aforeſaid *Problem* 1. *Caſe* 1. in *page* 135, is thus,

As theRadius .. T.c:Hypot.P*a* : : T·LegBP .. S.c AngleBP*a*.
As theT. 45d. .. T. 51d. 32m : : T. 20d. 12m. .. S 27d35m.

the *Sun's*Aſcenſional Difference, which is 01h. 50m. before *6*, his Riſing; and as much after *6*, is the *Sun's* Setting; becauſe its *North-Latitude*, and the Sun is in a *Northern-Sign*; but it's the contrary, when one is *North* and the other *South*.

In this Triangle may *Problem* 4, 5, 6, 7, 8, 9, 10, and 11, of *Section* 2. of this *Chapter* be ſolved.

Problem 3. *The ſame given as before in* Problem 2. *to find the* Sun's *Diſtance from the Vertex, when due Eaſt, or Weſt, and the Time from Noon when he ſhall be ſo.* *Plate* 8. *Figure* 1.

Example.

Latitude —— 51d. 32m. N. } *given*; *The* { *Sun's Zenith Diſtance.*
Sun's Place ♊ 00 00 } { *Time when he is Eaſt.*
or *Weſt Required.*

1. To delineate this; after the proper Meridian, and *Path* of the *Vertex*, or Parallel of Latitude is drawn, as before in *Problem* 1 and 2. Then thro' ☉ and D, draw a Great Circle, juſt to touch the *Path* of the *Vertex*, on either ſide of it, as the Oblique Circles ☉ c d, and ☉ d D

2. Through P and c; or P, and d; draw a Great Circle, to cut ☉ c d, or ☉ d D at Right Angles, in the Place of the *Vertex*, when the Sun ſhall appear due Eaſt, or Weſt: And then there is formed two Triangles, P c ☉, and P d ☉; one when the Sun is E. and the other when he is W; in each the ſame things are given and required. Therefore obſerve,

In the *Rectangle Triangle*, P c ☉. *Plate* 8. *Fig.* 1.

1. The Hypotenuſe P ☉ the *Sun's Diſtance* from the *Pole*, found by *Problem* 1. to be 69d. 48m. the Complement of the Reflection.

2. The Leg Pc, the Diſtance of the *Pole* from the *Vertex* or Complement of the Latitude, in this Example 38d. 28m.

3. The Leg ☉ c, the *Sun's Diſtance from the Vertex*, or Complement of his *Altitude* when *Eaſt*: and the ſame when *Weſt*

4. The Angle ☉Pc, the *Hour from Noon*, when he is or ſhall appear to be Eaſt, or Weſt.

1. For the Leg ☉ c, the *Sun's* Zenith Diſtance, the Proportion by *Chapter* 5. *Section* 4: *Problem* 1. *Caſe* 3. *in page* 135, and 136. is thus.

As

he S.c. Leg Pc. ·· Radius::S.c.*Hipot* ⊙P ·· S.c.Leg,⊙c.
he S. 51° 32′ ·· S. 90d :: S. 20d. 12m. ·· S.26.10.*Sun's Al-*
le when Eaſt, and the ſame when Weſt.

That is,

s the Sine of the *Latitude*, is to *Radius* ;
o is the Sine of the *Reflection*, to the Sine Complement of
Sun's Zenith Diſtance ; or his Diſtance from the *Vertex*, in
Caſe 63d, 50m.

For the *Angle* ⊙ P c, the *Hour from Noon*, the *Proportion*,
hus ;

adius ·· T. Leg Pc::Tc.*Hipot.* ⊙P ·· Sc.Angle ⊙Pc.
.45d.T.38d.28d. ::T.20d. 12m. ·· S. 17d. 00m. or 1h.8m

That is ;

s the *Radius*, is to the *Tangent Complement of the Latitude*;
o is the Tangent of the *Reflection*, to the *Sine Complement* of
Hour from Noon, when the Sun is due Eaſt, or Weſt;
is Caſe he is Eaſt at 8m. after 7 of the Clock in the Fore-
n, and Weſt at 52m. after 4 in the Afternoon.

this Triangle may *Problem* 18. 19, 20, 21, 22 and 23,
ection 2. of this *Chapter* be reſolved.

lem 4. *The ſame given as before* in Problem 2 *to find the*
n's Diſtance *from the* Vertex ; *and his* Azimuth *at the*
ur of Six, Plate 8. *Figure* 1.

Example

{ *Latitude*——51d.32m.N } given; *The Sun's* { *Zen Diſt.*
{ *Sun's Place* Ⅱ 00 00 } { *Azimuth*

ſix of the Clock, is required,

To Delineate this ; after the proper *Meridian*, and *Path*
e *Vertex* is drawn, as before in *Problem* 2. Then thro' P,
a Great Circle, at Right Angles with the proper *Meridi-*
o cut the Path in b, and in e; and the *Horizon of the Earth's*
in A; where it always interſects the *Equator*; as the Ob.
Circle A b P e, A b I e ; which is the *Meridian* or *Hour*
of 6, ſo that b (in the *Path*) is the Place of the *Vertex*
in the Morning; and e, its Place when 6 Afternoon.
Therefore thro' ⊙, and b ; or ⊙, and e ; draw a great
e, and you will form two Right Angled Triangles bP⊙,
⊙ ; one of them is ſufficient to ſolve the Queſtion, be-
qual Triangles: If you take the firſt at 6 in the Morn-
it follows.

the Right-angled Triangle bP⊙. *Plate* 8. *Figure* 1.

The Leg Pb ; the Diſtance of the *Pole* from the *Vertex*.

2. For the Angle BP*a*, the Complement of the Aſ ſional Difference, the Proportion by the aforeſaid *Proble* *Caſe* 1. in *page* 135, is thus,

As the Radius .. T.c:Hypot.P*a* : : T·LegBP .. S.c AngleI
As the T. 45d. .. T. 51d. 32m : : T. 20d. 12m. .. S 27d3

the *Sun's* Aſcenſional Difference, which is 01h. 50m. befo his Riſing; and as much after 6, is the *Sun's* Setting; bec its *North-Latitude*, and the Sun is in a *Northern-Sign*; bu the contrary, when one is *North* and the other *South*.

In this Triangle may *Problem* 4, 5, 6, 7, 8, 9, 10, and of *Section* 2. of this *Chapter* be ſolved.

Problem 3. *The ſame given as before in* Problem 2. *to fin* Sun's *Diſtance from the Vertex, when due Eaſt, or Weſt*, *an* *Time from Noon when he ſhall be ſo.* *Plate* 8. *Figure* 1.

Example.

Latitude —— 51d. 32m. N. } *given*; The { *Sun's Zenith Diſt*
Sun's Place ♊ 00 00 } { *Time when he is*
or *Weſt Required.*

1. To delineate this; after the proper Meridian, *Path* of the *Vertex*, or Parallel of Latitude is drawn, as be in *Problem* 1 and 2. Then thro' ⊙ and D, dr Great Circle, juſt to touch the *Path* of the *Vertex*, on ei ſide of it, as the Oblique Circles ⊙ c d, and ⊙ d D

2. Through P and c; or P, and d; draw a Great to cut ⊙ c d, or ⊙ d D at Right Angles, in the Place *Vertex*, when the Sun ſhall appear due Eaſt, or Weſt: then there is formed two Triangles, P c ⊙, and P d ⊙; when the Sun is E. and the other when he is W; in the ſame things are given and required. Therefore obſer

In the *Rectangle Triangle*, P c ⊙. *Plate* 8. *Fig.* 1.

1. The Hypotenuſe P ⊙ the *Sun's Diſtance* from the found by *Problem* 1. to be 69d. 48m. the Complemen the Reflection.

2. The Leg Pc, the Diſtance of the *Pole* from the *V* or Complement of the Latitude, in this Example 38d.

3. The Leg ⊙ c, the *Sun's Diſtance from the Vertex*, or plement of his *Altitude* when *Eaſt*: and the ſame when

4. The Angle ⊙Pc, the *Hour from Noon*, when or ſhall appear to be Eaſt, or Weſt.

1. For the Leg ⊙ c, the *Sun's* Zenith Diſtance, the portion by *Chapter* 5. *Section* 4: *Problem* 1. *Caſe* 3. *in page* and 136. is thus.

As the S.c. Leg Pc. ·· Radius::S.c.*Hipot* ⊙P ·· S.c.Leg,⊙c.
As the S. 51° 32′ ·· S. 90d :: S. 20d. 12m. ·· S.26.10.*Sun's Altitude* when Eaſt, and the ſame when Weſt.

That is,

As the Sine of the *Latitude*, is to *Radius* ;
So is the Sine of the *Reflection*, to the Sine Complement of the *Sun's Zenith Diſtance* ; or his Diſtance from the *Vertex*, in this Caſe 63d, 50m.

2. For the *Angle* ⊙ P c, the *Hour from Noon*, the *Proportion*, or thus ;

As Radius ·· T. Leg Pc::Tc.*Hipot* ⊙P ·· Sc.Angle ⊙Pc.
As T.45d.T.38d.28d. ::T.20d. 12m. ·· S. 17d. 00m. or 1h.8m

That is ;

As the *Radius*, is to the *Tangent Complement of the Latitude* ;
So is the Tangent of the *Reflection*, to the *Sine Complement* of the Hour from Noon, when the Sun is due Eaſt, or Weſt; In this Caſe he is Eaſt at 8m. after 7 of the Clock in the Forenoon, and Weſt at 52m. after 4 in the Afternoon.

In this Triangle may *Problem* 18. 19, 20, 21, 22 and 23, of *Section* 2. of this *Chapter* be reſolved.

Problem 4. *The ſame given as before* in Problem 2 *to find the* Sun's Diſtance *from the* Vertex ; *and his* Azimuth *at the Hour of Six, Plate* 8. *Figure* 1.

Example

The { *Latitude*——51d.32m.N
{ *Sun's Place* ♊ 00 00 } *given* ; *The Sun's* { *Zen Diſt.*
{ *Azimuth*
at ſix of the Clock, is required,

1. To Delineate this ; after the proper *Meridian*, and *Path* of the *Vertex* is drawn, as before in *Problem* 2. Then thro' P, draw a Great Circle, at Right Angles with the proper *Meridian*, to cut the Path in b, and in e; and the *Horizon of the Earth's Diske* in A; where it always interſects the *Equator*; as the Oblique Circle A b P e, A b I e ; which is the *Meridian* or *Hour-Circle* of 6, ſo that b (in the *Path*) is the Place of the *Vertex* at 6 in the Morning; and e, its Place when 6 Afternoon.

2. Therefore thro' ⊙, and b ; or ⊙, and e ; draw a great Circle, and you will form two Right Angled Triangles bP⊙, or eP⊙ ; one of them is ſufficient to ſolve the Queſtion, being equal Triangles: If you take the firſt at 6 in the Morning ; it follows.

In the Right-angled Triangle bP⊙. *Plate* 8. *Figure* 1.

1. The Leg Pb ; the Diſtance of the *Pole* from the *Vertex*.

or the *Complement of the Latitude*; in this *Example* 38d. 28m.

2. The Leg P⊙, the *Sun's* Diſtance from the *Pole* found by *Prob.* 1. to be 69d. 48m. the Complement of the Reflection.

3. The Hypotenuſe b⊙, the *Sun's Diſtance from the Vertex*, or Complement of his *Altitude* at the Hour of 6.

4. The Angle Pb⊙, his *Azimuth* from the North, in all North Latitudes, and the contrary in South Latitudes: For in what part of the *Path* ſoever the Vertex is found, that part of the Hour Circle, intercepted betwixt it and the *North Pole* of the Globe, is the North-part of that Meridian, or Hour-Circle; and intercepted betwixt it and the South Pole, is the South part of the Meridian.

5. For the Hypotenuſe b⊙ the *Sun's* Zenith Diſtance at the Hour of 6, the Proportion (by *Chapter* 5. *Section* 4. *Problem* 5. *Caſe* 14 *in page* 139. *and* 140.) is thus;

Radius .. S. c. Leg P b : : S c. Leg P ⊙ .. S.c. Hypot. b ⊙.
S 90d. .. S. 51d. 32m : : S. 20d. 12m. .. S. 15d. 41m. Sun's Altitude at 6 in the Morning or Afternoon.

That is;

As the Radius is to the Sine of the Latitude;
So is the Sine of the Reflection, to the Sine of the Sun's Altitude, or Complement of his Diſtance from the Vertex, at the Hour of 6, 74d. 19m.

2. For the Angle Pb⊙, his Azimuth at 6, the Proportion is thus;

As Radius S. Leg Pb : : T.c. Leg P⊙ .. T c. Angle Pb⊙.
As S. 90d. .. S. 38d. 28m. : : T 20d. 12m. .. T 12d. 53m. *Sun's* Azimuth from the Eaſt, at 6 in the Morning; but from the Weſt at 6 in the Afternoon.

That is;

As the Radius is to the Sine Complement of the Latitude;
So is the Tangent of the Reflection, to the Tangent Complement of the Sun's Azimuth from the Meridian, at the Hour of 6 in this Caſe it's 77d 07m. from the North; that is, almoſt E. by N. at 6 in the Morning, and near W. by N. at 6 in the Afternoon.

In this Triangle may *Problem* 12, 13, 14, 15, 16, and 17. of *Section* 2. *of this Chapter* be ſolved.

Problem 5. *The Sun in the Equinox, the Latitude of a Place, and his Altitude given; to find his Azimuth, and Hour of the Day.*

Note; the Sun is ſaid to be in the *Equinox*, when he is in the beginning of ♈, or ♎; and then he hath no Declination.

Ex. The { *Latitude* 51d.32 N. / ⊙ *Altitude* 33d. A.M. } *given*: The { *Sun's Azimuth.* / *Hour of the Day* }
Required. To delineate this. *Plate* 8. *Figure*. 1.

1. Suppoſing the Sun in the beginning of ♈, and then the Horizon of the Earth's Diske is ♋ PK ♑, and the proper Meridian then is ♈P♎: the Sun's Riſing at *London* is at m, his Setting at t, *&c.* The Path of the Vertex being drawn as before in *Problem* 2.

2. Then (by *Problem* 9. *Caſe* 2. of *Spherical Geometry*, in page 121.) draw a Parallel-Circle at 57d. diſtance from ♈, to cut the Path in b; the place of the Vertex of *London*, when its Diſtance from the Sun is 57d. the Complement of the given Altitude.

3. Draw a Meridian through P and b; as alſo a Great Circle through b and ♈, the place of the Sun, ſo will you form the Triangle ♈Pb, and bPK; either of them will ſolve the Queſtion: As,

In the Right Angle Triangle PKb. *Plate* 8. *Figure* 1.

1. The *Hypotenuſe* Pb, the Diſtance of the Pole from the Path of the Vertex, or Complement of the Latitude, 38d. 28m.

2. The Leg Kb, the Sun's Altitude, or the Complement of his Diſtance from the Vertex, 33 Degrees.

3. The Angle PbK (the Supplement of the Angle Pb♈, the Sun's Azimuth from the North) the Sun's Azimuth from the South, in all North Latitudes; but from the North in South Latitudes.

4. The Angle bPK, (the Complement of the Angle bP♈ the *Hour from Noon*) is the Hour of the Day from 6.

1. For the Angle PbK, the Azimuth from the Meridian, the *Proportion* (by *Chapter* 5. *Section* 4. *Problem* 1. *Caſe* 1. in *page* 135.) is thus;

As Radius .. T.c. *Hypot.*Pb : : T.Leg Kb .. S c. Angle PbK.
As T. 45d .. T.51d. 32m. : : T. 33d. .. S 54d. 49m. the *Sun's* Azimuth from the Eaſt. That is;

As the Radius, is to the Tangent of the Latitude;
So is the Tangent of the Sun's Altitude (when in the Equinox) to the Sine Complement of his Azimuth from the *South*, that is 35d. 11m. *S. E.erly*, or *S.E.* by *S.½E* almoſt;

2. For the Angle PbK, the Hour from 6. the *Proportion* is thus;

As S.Hypot. Pb .. Radius :: S. Leg Kb .. S Angle bPK.
As S.38d. 28m. .. S.90d. :: S. 33d. .. S.61d. 06m. or 4h. 4m

That is ;

As the Sine Complement of the Latitude is to the Radius ;

So is the Sine of the Sun's Altitude (when in the *Equinox*) to the *Sine* of the Hour from 6 : 61d. 06m. equal to 4h. 4m. which makes 4m. after 10 in the Morning ; but had it been in the Afternoon, then it's 56m. after 1.

In the ſame Triangle, 5 *Problems* more may be reſolved, which I leave the Learner to invent.

Problem 6. *The Latitude of a Place, the Sun's Place in the Ecliptic, and his obſerved Diſtance from the Vertex given ; to find his* Azimuth, *and Hour of the Day.* Example.

The { *Latitude*—— 51.32N. / *Sun's Place* ♊ 00.00 / *His Altitude* 36.00 A.M. } *given : The* { *Suns Azimuth* / *Hour of the Day* } *required.*

To delineate this, *Plate* 8. *Figure* 1.

1. Draw a Parallel Circle, 54d. Diſtance from ⊙, (the place of the *Sun*) and where it cuts the *Path* (of the *Vertex*) is the place of the *Vertex*, when it's Diſtance from the *Sun* is 54d. or when the *Sun's Altitude* is 36d. as here it doth at 7 and 5.

2. Thro' 7, and P ; and thro' 7, and ⊙ ; draw Great-Circles, which will form the Triangle ⊙ P7 ; the like may be done thro' 5, which will form another Triangle equal in all its parts to this, ſo that one is ſufficient ; wherefore obſerve,

In the *Oblique Triangle* ⊙P7. *Plate* 8. *Figure* 1.

1. The Side P ⊙, the Diſtance of the *Sun* from the *Pole*, found by *Problem* 1. to be 69d. 48m the Complement of the Reflection 20d. 12m.

2. The Side P7, the Diſtance of the *Pole* from the *Vertex*, or the *Complement of the Laritude*, in this Example 38d. 28m.

3. The Side ⊙7, the *Sun's* Diſtance from the *Vertex*, or the Complement of his Altitude in the Forenoon 54d. 00m.

4. The Angle P7⊙, the *Sun's* Azimuth from the North.

5 The Angle D ⊙P7, *the Hour of the Day from Noon.*

The Angles P7⊙ and ⊙P7 may be found by *Chapter* 5. *Section* 5. *Problem* 11. *Caſe* 11. *of Oblique Spherical Trigonometry*, in *page* 147, and 148. for here are 3 Sides given ; to find an Angle ; and when wrought you'll find the Angle P7⊙ 103d. 12

12m. the Azimuth, from the North, or 76d. 48m. from the South Eaſterly, which makes E. by S. almoſt.

And the Angle ⊙ P 7 is 57d. 04m. or 3h. 48m. the Hour from Noon, which makes 12m. after 8 in the Morning.

But had it been in the Afternoon, then the Hour would be 48m. after 3, and the Azimuth 76d. 48m. South Weſterly or W. by S. almoſt.

In this Triangle may *Prob.* 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10 of *Section* 3. of this *Chapter* be ſolved.

Problem 7. *The Longitude and Latitude of a Star given; to find its Right Aſcenſion and Declination.*

Example. *Let the propoſed Star be* Capella, *and ſuppoſing it's*

Longitude ♊ 18d. 02m. } *what is it's* { *Right Aſcenſion?*
Latitude —— 22d. 52m. *North* } { *Declination?*

To delineate this *Problem.* *Plate* 8. *Figure* 1.

1. Lay off the Star's Longitude 78d. 02m. (from the Chords) on the Primitive Circle, from ♈ to y, and draw the Circle of Longitude K y.

2. From the Half Tangents lay 67d. 08m. (the Complement of the Star's Latitude, or its Diſtance from the neareſt Pole of the Ecliptick) on the Circle of Longitude from K to ✳.

3. Thro' P, and ✳, draw a Meridian, that is a Great Circle, and its done.

Then in the Oblique Triangle KP✳, *Plate* 8. *Figure* 1. Obſerve;

1. The Side PK, the Diſtance of the two Poles, or Line of Direction of the Earth's Axis always; 23d. 30m.

2. The Side K✳, the *Star's Diſtance from the Pole of the Ecliptic,* or its Complement of Latitude, equal to 67d. 08m.

3. The Angle PK✳, the Star's Longitude from the *Solſtitial Colure,* in this Problem is 11d. 58m.

4. The Angle KP✳, the Star's Right Aſcenſion from the ſame Colure.

5. The Side P✳, the Star's Diſtance from the Pole of the Globe; or Complement of his Declination.

So that here are two Sides, and an Angle between them given; to find an Angle, and the third Side; which is performed by *Chapter* 5. *Section* 5. *Problem* 9. *Caſe* 7. *and* 8. *of Oblique Spherical Triangles; in page* 144 *and* 145. and being the ſame as *Problem* 11. *of Section* 3. of this *Chapter, in page* 234. I leave it to the Learner's Working.

Problem 8, *The Latitude of a place, the Sun's place in the Ecliptic, and the time of the Day given; to find what point of the Ecliptic Culminates in the Meridian; the Higheſt Point in the Ecliptic (called the* Nonageſima Degree *or 90th* Degree, *of the Ecliptic) the Diſtance of each of theſe from the* Vertex, *and the* Parallactic Angle, *or Angle which the Vertical Circle makes with the Ecliptic.*

It's uſual to find theſe things in the Calculation of *Eclipſes*, and the *Moons* paſſing over *Fixed Stars*; which in the *Ptolomaic Projection*, are with much Difficulty ſhewn, but in this moſt readily and eaſily repreſeuted.

Example.

Latitude —— 51.32 N
Sun's place ♊ 0.00
Hour ——— 9h. A M
given; *the*
Point Culminating
Nonigeſſima Degree
Vertical Diſtance of each

Required. To delineate this. *Plate* 8. *Figure* 1.

1. The Sun's place, proper Meridian, and Path of the *Vertex*, being drawn as before, draw an Hour Circle, or Meridian thro' P, 45d. (the Diſtance of the given Hour 9) from the proper Meridian, as P9, to cut the Path of the Vertex in 9, and the Earth's Ecliptick in C, and in F.

2. Thro' ☉ 9, and D, draw a Vertical Circle; and thro' K, and 9, draw a Circle of Longitude, to cut the Primitive Circle in N, and it's done. For,

1. C is the point of the Ecliptick Culminating, or in the Meridian of the Place, at the given time.

2. N is the *Nonageſſima Degree*, or the higheſt point of the Ecliptick, at the ſame time.

3. C9, and N9, are their reſpective Diſtances, from *London's Vertex* at that time.

4. The Angle N☉9, is the Parallactic Angle, or Angle which the *Vertical* Circle, makes with the Ecliptic at the ſame time.

Then the Rectangle Triangle P ♋ C.

1. The Angle CP ♋, is the Complement of the Right Aſcenſion of the *Mid-heaven*, or point of the Ecliptic in the Meridian of the place at the propoſed Time, being the Time from Noon (when Afternoon added to the Sun's Right Aſcenſion, found by *Problem* 1. But when the propoſed Time is in the Forenoon ſubtracted) in this Caſe is 77d. 11m, the Complement of 12d. 49m. found by ſubtracting (the Time) 45d. from 57d. 49m. the Sun's Right Aſcenſion.

2. The Leg P♋, is the Complement of the Diſtance of the Poles of the Globe, and Ecliptic, equal to 66d. 30m.

3. The Leg C♋, is the Complement of ♈ C, the Longitude of the *Mid heaven*, or the Point of the Ecliptic Culminating in the Meridian, at the propoſed Time.

4. The Hypotenuſe CP, the Diſtance of the *Mid-heaven* from the next or neareſt Pole of the Globe, at the ſaid Time.

1. For the Leg C♋, the Point Culminating, the *Proportion by Chapter* 5. *Section* 4. *Problem* 3. *Caſe* 7. in *page* 137 and 138 is thus;

As Radius S. Leg P♋ :: T. Angle CP♋ ·· T.Leg. C♋.

As S. 90d. ·· S. 66d.30m, :: T.77d.11m. ·· T 76d. 02m. whoſe Complement 13d. 58m. is ♈C; therefore the *Mid-heaven* is ♈ 13d. 58m.

2. For the Hypotenuſe CP. the *Proportion* is thus;

Radius ·· Sc. AngleCP♋ :: T.c.LegP♋ ·· T c. Hypotenuſe CP.

S. 90d. ·· S. 12d. 48m. :: T. 23d. 30m. ·· T. 05d. 30m. whoſe Complement 84d. 30m. is PC, from which take away P9 the Diſtance of the *Pole* from the *Vertex* 38d. 28m. the Remainder is 9C, the Diſtance of the *Mid-heaven* from the *Vertex* 46d. 02m. Then in the Oblique Triangle P9K.

1. The Side PK, the Diſtance of the two *Poles* 23d. 30m.

2. The Side P9, the Complement of the Latitude of the Place, 38. 28m.

3. The Angle KP9, the Difference of the Right Aſcenſion of the *Mid-heaven*; and firſt Point of ♑; in this Caſe 102d. 48m. found by ſubtracting 270 Degrees, out of (12d. 48m. added to 360 Degrees being) 372d. 48m.

4 The Angle PK9, the Longitude of the *Nonageſima* from the firſt Point of ♋.

5. The Side K9, the Complement of the *Nonageſima's* Diſtance from the *Vertex*.

Firſt, For the Angle PK9, the *Proportion* by *Chapter* 5. *Section* 5. *Problem* 9. *Caſe* 7. *in page* 144, and 145. is thus,

1. As the Sine of ½ the Sum of the Sides P9, and PK, is to the Sine of ½ their Difference;

So is the Tangent Complement of ½ the Angle KP9, to the Tangent of half the Difference of the Angles PK9, and P9K Then,

2. As the Sine Complement of ½ the Sum of the Sides P9, and PK, is to the Sine Complement of half their Difference;

So is the Tangent Complement of half the Angle KP9, to the Tangent of half the Sum of the Angles PK9, and P9K.

That is,

d.m. d.m. d.m. d.m.

1. As the S. 30.59 .. S. 07.29 : : T. 38.36 .. T. 11.25. And
2. As the S. 59.01 .. S. 82.31 : : T. 38.36 .. T. 42.43. Which

being added, is the Angle PK9 —— —— 53.08 or ⊙N.
ſubtract from —— —— —— —— 90.00

Remainder is the Longitude of the *Nonageſima* 35.52 from ♈.

That is, the Place of the *Nonageſima* is 5d. 52m. in ♉.

Secondly, For the Side K9, the *Proportion* is thus;

As S. Angle PK9 .. S. Side P9 : : S. Angle KP9 .. S. Side K9.
As S. 54d. 08m. .. S. 38d. 28m. : : S. 102d. 48m. .. S. 48d. 28m.
the Diſtance of the Vertex from the Pole of the Ecliptic, equal to which is the Altitude of the *Nonageſima*, whoſe Complement 41d. 32m. is N9, its Diſtance from the Vertex.

Again, in the Rectangle Triangle ⊙N9.

1. The Leg ⊙N, the Sun's Diſtance from the *Nonageſima*, in this Caſe 24d. 08m. found by ſubtracting ♈N 35d. 52m. from ♈⊙ 60d, 00m.

2. The Leg N9, the Diſtance of the *Nonageſima* from the Vertex; found as before is 41d. 33m.

3. The Hypotenuſe ⊙9, the Sun's Diſtance from the *Vertex.*

4. The Angle N⊙9, made between the Vertical-Circle and the Ecliptic, is the *Parallactic Angle*: to find which, the *Proportion* (by *Chapter* 5. *Section* 4. *Problem* 5. *Caſe* 13. *in page* 139, *and* 140) is thus,

As Radius .. S. Leg ⊙N : : T.c. Leg N9 .. T.c. Angle N⊙9.
As S. 90d. .. S. 24d. 08m. : : T. 48d. 28m. .. T. 24d 47m. whoſe
Complement 65d. 13m. is the *Parallactic Angle* N⊙9 at the Sun.

And for ⊙9, the Sun's Diſtance from the Vertex, is thus found.

As Radius .. S.c. Leg ⊙N : : S.c. Leg N9 .. S.c. Hypot. ⊙9.
As S. 90d. .. S. 65d 52m : : S. 48d. 47m .. S. 43d. 05m. whoſe
Complement 46d. 55m. is the Sun's Diſtance from the Vertex, at the propoſed Time.

But to Calculate the *Parallactic Angle*, at the *Moon*, or at a *Star*, that has Latitude from the Ecliptic, it will require a little more Labour, as in the next Problem.

Problem 9. *The Latitude of a Place, Sun's Place in the Ecliptic, Time of the Day or Night, and the Longitude, and Latitude of the* Moon, *or of a* Star, *being given; to find the* Parallactic Angle at the Moon, or at the Star; and its Diſtance from the Vertex.

Example

Latitude 51.32 N
Sun's Place —— ♊ 0.00
Hour —— 9h. A. M.
Star Capella Long. 18.02 ♊
Its Latitude 22.52 N
} *given: The* { *Parallact. Ang.* *and* *Vertical Diſt.* } *requir.*

To delineate this. *Plate* 8. *Figure* 1.

1. Lay off the *Sun's* Longitude, and draw the proper Meridian Path of the Vertex, the Hour Circle according to the propoſed Time, the Vertical Circle, and Circle of Longitude, in all reſpects as before in *Problem* 8.

2. Lay off the Star's Longitude and Latitude, as before in *Problem* 7. and then is N the Place of the *Nonageſima*, 9 the Vertex, and ✳ the Star's Place.

3. Through ✳, and 9, draw a Great Circle, and it's done. For ✳9, is the Star's Diſtance from the Vertex; and the Angle K✳9, the Complement of the Parallactic Angle required: In order to the finding them by *Calculation*, do thus;

Firſt, Find the Place of the *Nonageſima* by *Problem* 8, which in this Caſe is ♉ 5d. 52m. or ♈ N. 35d. 52m.

Secondly, The *Nonageſima's Diſtance* from the Vertex, in this Caſe N9, is 41d. 32m.

Then in the Oblique Triangle ✳K9, obſerve,

1. The Side K✳, the Star's Diſtance from the next *Pole* of the Ecliptic or the Complement of its Latitude; 67d. 08m.

2. The Side K9, the Diſtance of the Vertex from the ſaid *Pole*, which is equal to the Altitude of the *Nonageſima*, 48d. 28m found by *Problem* 8.

3. The Angle ✳K9, the Difference of the Longitude of the given Star, and the *Nonageſima*; and in this Example is 42d. 10m. and is the Difference of ♈ N 35d. 52m. and ♈ y 78d. 02m.

4. The Angle K✳9, the Complement of the Parallactic Angle, at the given Star.

5. And the Side ✳9, the *Star's* Diſtance from the Vertex.

Firſt, To find the Angle K✳9, the Proportion by *Chap.* 5. *Section* 5. *Problem* 9. *Caſe* 7. in *page* 144 *and* 145. is thus,

1. As the S. of half the Sum of the Sides K✳, and K9; is to the Sine of ½ their Difference: So is the Tangent Comple-

ment of ½ the Angle ✻K9; to the Tangent of ½ the Difference of the Angles K 9 ✻and K ✻9. Then,

2. As the SineComplement of ½ the Sum of the Sides K ✻, and K 9; is to the Sine Complement of ½ their Difference: So is the Tangent Complement of ½ the Angles ✻K9; to the Tangent of ½ the Sum of the Angles K9✻, and K✻9.

That is;

d. m. d. m. d. m. d. m.
1. As the S. 57.48 .. S. 9.20 : : T.68.55 .. T.26.26. And,
2. As the S. 32.12 .. S 80.40: :T.68.55 .. T.78 14. They being Subtracted gives the Angle K ✻ 9 —— 51.48 whoſe Complement 38d. 21m. is the Parallactic Angle at *Capella.*

Secondly, To find ✻ 9, the Vertical Diſtance, the *Propor.* is thus,
As S. Angle K✻9 .. S. Side K9 : : S. Angle ✻K9 .. S. Side ✻9.
As S. 51d. 48m. .. S. 48d. 28m. : : S. 42d. 10m. .. S. 39d. 45m.

The Diſtance of the Star *Capella* from the Vertex at the Time propoſed.

I might proceed to other *Problems*, and ſhew how they are formed and repreſented in this *Projection*, but I leave that for the Learner's Exerciſe.

I paſs by what (at firſt) I intended, which was the Orthographical Projection of the Globe; whereby the *Moon's Appulſes* to the *Sun*, or *Stars*, and all the appearances of an Eclipſe, Occultation or Tranſit, are repreſented to the Eye: uſeful to find the Longitude of Places, on the Globe of the *Earth*, a thing much talk'd of, greatly deſired, and by ſome pretended to be found, tho' not made known, and I believe will never be made practicable at Sea. However, by this Hypotheſis, with accurate Tables of the *Moon* and *Stars* Places; and a way of taking an *Altitude* or an *Angle* at *Sea* unto two or three Minutes; it might be made uſeful to obſerve for Longitude, and therefore it's highly worthy of our *Seaman's* Study, but without ſuch *Altitudes*, it will not find the *Longitude* unto two or three Degrees: and for Encouragement hereunto the *Government* hath by an *Act of Parliament* promiſed *Thouſands of Pounds*; and for the *Learner's* help herein, I am ready to communicate all the Aſſiſtance I can elſewhere; for here's now no Place for it, leſt the Book (ſwelling too big) ſhould be deform'd.

And note; Theſe two Figures in *Plate* the 8*th*, are a Repreſentation of the two *Hemiſpheres* before deſcribed in *Chapter* 6. *Section* 4. in *page* 180 and 181. So that in thoſe larger; all theſe Problems might be more exactly formed, and their

Requiſites more truly meaſured; and if the particular Circles belonging to any *Problem*, ſuch as the proper Meridian, other *Meridians*, or *Hour Circles, Path of the* Vertex, *Circles of* Longitude, *and* Vertical Circles, *to a particular time*, &c. were drawn with *Black Lead*, they might be wiped out at pleaſure, and the *Hemiſpheres* no way damnified.

And when any Circle happens ſo large as not eaſily to be drawn, or ſtruck with Compaſſes, it may be done with a *Bow* of the length of the Diameter of the *Hemiſpheres*; ſuch being well made with 3 Screws, by their turning, will riſe up to ſeveral Circles, that may (in the *Projection*) be required to be drawn.

CHAP. X. *Of the Variation of the Compaſs, what it is, how to find it, and how to rectify the Compaſs thereby.*

DEfinition 1. *Variation of the Compaſs*, is an Arch of the *Horizon* contained between the Meridian of the Place, and the Magnetical Meridian; its either Eaſt, or Weſt, and never exceeds 90 Degrees.

2. *Eaſt Variation*, is when the North part of the Magnetical Meridian lieth Eaſtward of the North part of the Meridian of the Place; but if to the Weſtward, then it is called *Weſt Variation.*

3. *Magnetical Meridian*, is a great Circle paſſing thro' or by the *Magnetical Poles*; to which Meridian the Compaſs (if not otherwiſe hindered) hath reſpect.

4. *Magnetical Poles*, are two moving oppoſite Points, making their Revolution about the Poles of the World (as Mr. *Bond* ſaith in his *Longitude found, page* 7.) in 600 Years in a Circle 8d. 30m. diſtant therefrom; and their Motion (as he ſaith) is the Cauſe of the Variation of the Compaſs.

5. The *Variation of the Compaſs* is found by an *Amplitude*, or an *Azimuth.*

6. To find the *Variation* by an *Amplitude*, you muſt know the Latitude of the Place, the Declination, and Magnetical Amplitude of the Sun.

7. *Magnetical Amplitude*, is an Arch of the *Horizon*, contained between the *Sun* (at his Riſing, or Setting) and the Eaſt or Weſt points of the *Compaſs ſteered by*: Or, it's the apparent Riſing, or Setting of the Sun from the Eaſt, or Weſt-points of the ſaid Compaſs, and is found by obſerving the Sun, either at his Riſing, or Setting by an Amplitude Compaſs.

8. *Amplitude*, is an *Arch* of the *Horizon*, contained between the *Sun* and the *Eaſt*, or *Weſt Points* of the *Horizon*; and is found by *Chapter 9. Section 2. Problem 4.* in *page* 216 and 217 which I call the *True Amplitude*.

9. If the two foreſaid *Amplitudes* agree; that is, the *Magnetical* and *True Amplitude* (which is ſeldom) there is no Variation; but if they Differ, their Difference rightly counted is the Variation.

Note here; If you always count both *Amplitudes* from the *North*; then this is a *General Rule*.

$$\text{At } \textit{Sun Riſing} \left\{ \begin{array}{l} \textit{True} \text{ ——} \\ \textit{Magnetical} \end{array} \right\} \textit{Amplitude} \text{ greateſt, the}$$

$$\textit{Variation} \text{ is} \left\{ \begin{array}{l} \textit{Eaſt} \\ \textit{Weſt} \end{array} \right\} \text{ But at } \textit{Sun Setting} \text{ it's} \left\{ \begin{array}{l} \textit{Weſt} \\ \textit{Eaſt} \end{array} \right.$$

Example 1. At *Sun Riſing*, ſuppoſe the *True Amplitude* be Eaſt 33 Degrees Northerly, and the *Magnetical Amplitude* Eaſt 17 Degrees Northerly; then counting both theſe from the *North*, the *True Amplitude* will be North 57 Degrees Eaſterly, and the *Magnetical* North 73 Degrees Eaſterly; the *Magnetical* is the greateſt, and the Difference is 16 Degrees, which is the *Variation* Weſterly: If this had been at *Sun-ſetting*, the *Variation* would then be Eaſterly.

Example 2. At *Sun-ſetting* let the True *Amplitude* be Weſt 16 Degrees Northerly, and the *Magnetical Amplitude* Weſt 9 Degrees Southerly; both counted from the North, the *True Amplitude* is North 74 Degrees Weſterly, and the *Magnetical* is 99 Degrees from the North, and is the greateſt; their Difference is 25 Degrees, which is the *Variation* Eaſterly.

Or thus, in theſe *two Rules*:

1. The *Amplitudes* both North, or both South; their Difference is the *Variation*: But one North, the other South, their Sum is the Variation.

2. Both the *Amplitudes* (before your Face) from you, if the *True Amplitude* be to the Right-hand of the *Magnetical*, the *Variation* is Eaſt; but when it's to the Left-hand, then the *Variation* is Weſt.

Theſe *Rules* will be examplified in the *Problem* and *Examples* following.

Problem 1. *The* Latitude *of the Place, the* Declination, *and* Magnetical Amplitude *of the Sun given; to find the* Variation *of the* Compaſs.

Plate 8 Fig 1.

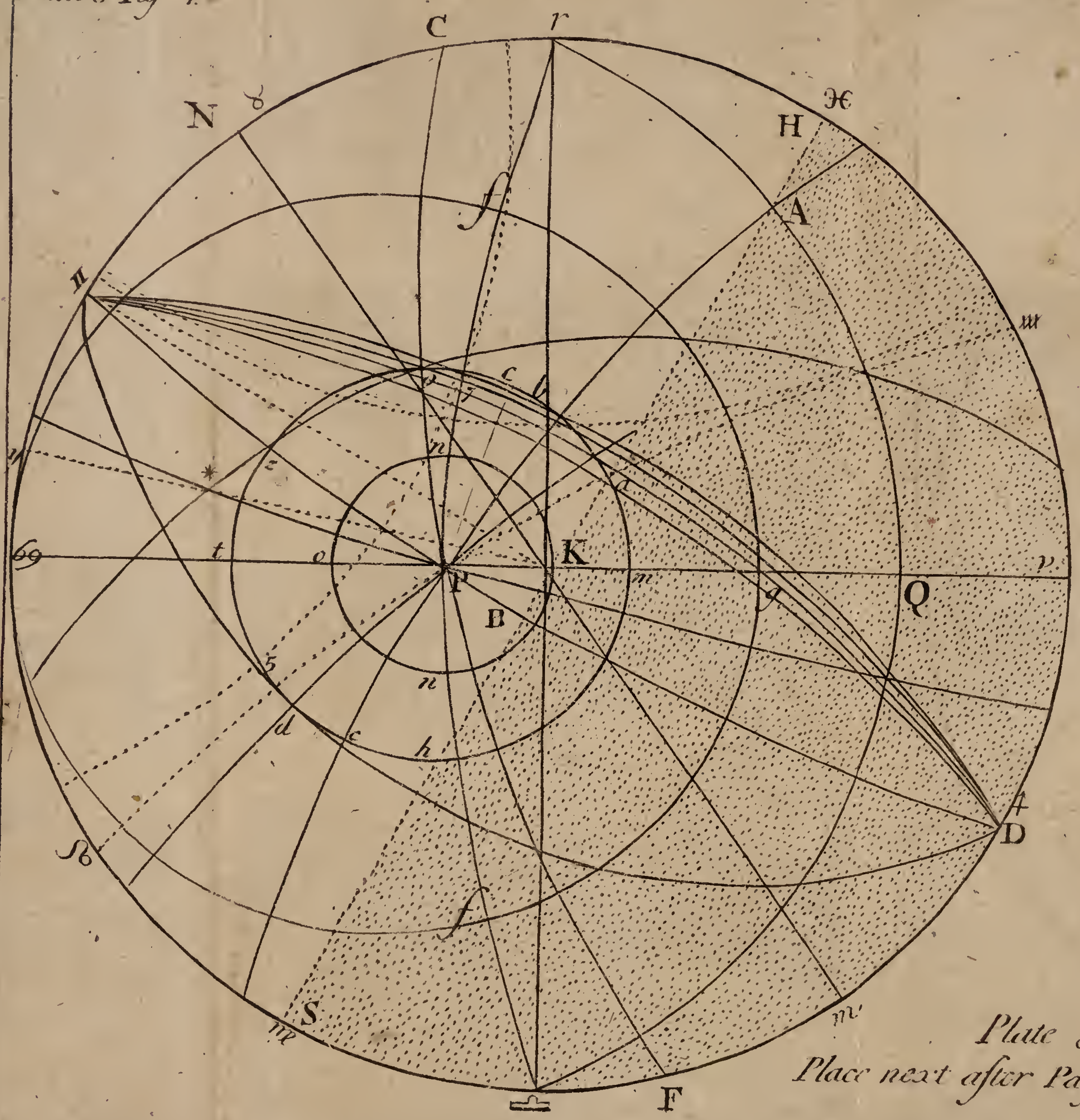


Fig 2.

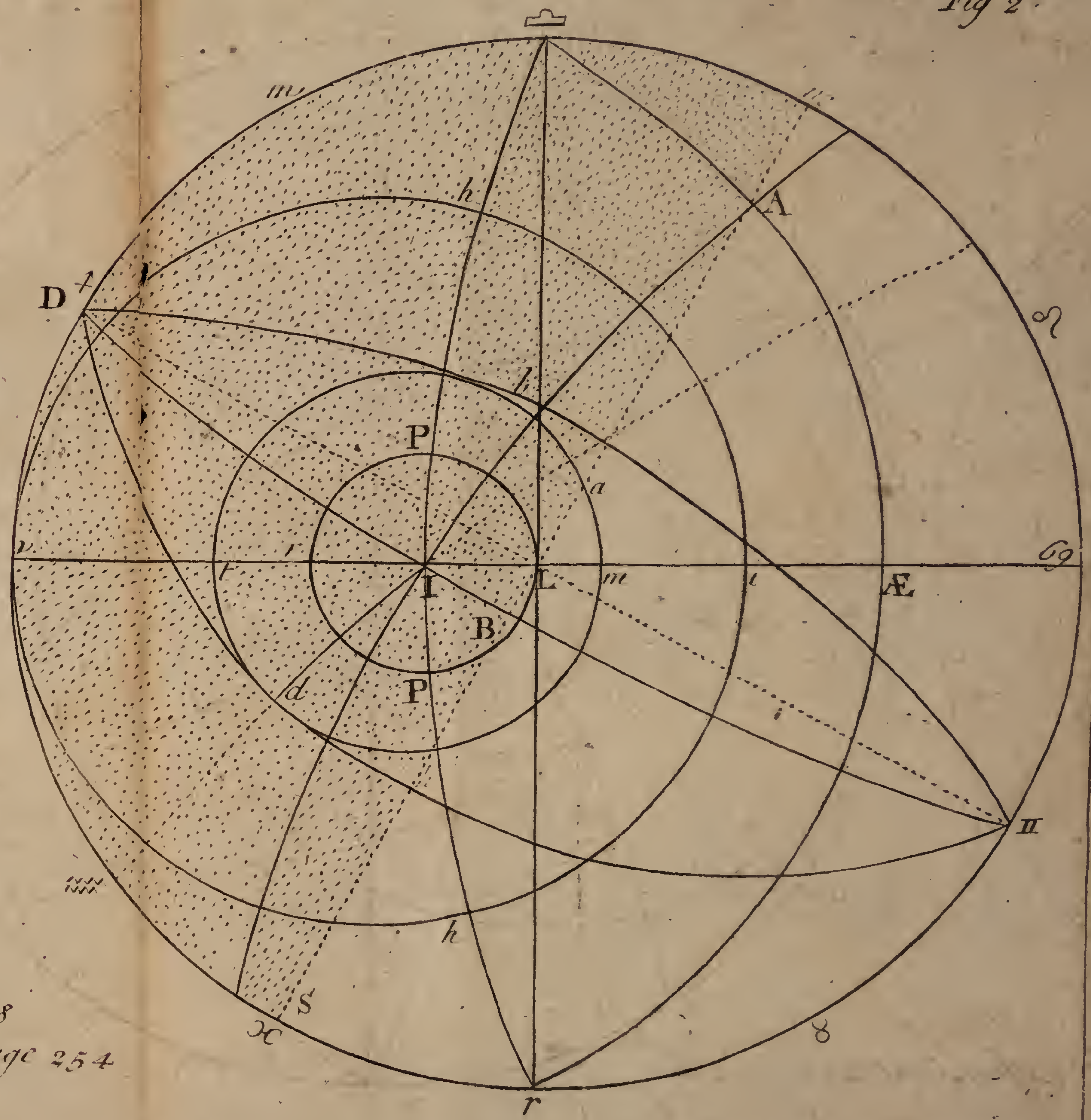


Plate 8
Place next after Page 254

Example.

The { Latitude ———— 51d, 32m. }
{ Sun's Declination —— 20 10 } *North given* ;
{ Magnetical Amplitude 17 10A.M. } *The Variat. Req.*

To delineate the Problem Orthographical. Plate 9. *Figure* 1.

1. Deſcribe a Circle and Quarter it ; on whoſe Diameters place W. N. E. and S. (but always) N at the Right Hand, and A at the Center of the Circle.

2. Lay the Lat if $\left\{\begin{matrix}\textit{North}\\ \textit{South}\end{matrix}\right\}$ from $\left\{\begin{matrix}\text{N}\\ \text{S}\end{matrix}\right\}$ upward s to $\left\{\begin{matrix}\text{P}\\ \text{I}\end{matrix}\right\}$ and the ſame way laid from W. to Æ, and draw the Axis PAI, and the Equinoctial Æ A Q.

3. By laying the Chord of the Declination on the Primitive Circle, from the Equinoctial, draw the Parallel of Declination parallel to it ; as the ſtrait Line d C e, to cut the Horizon SAN, in C, the place of the Sun's Riſing, or Setting.

4. Meaſure A C on the Line of Sines, ſheweth the Sun's True Amplitude North, if the Declination be North: but South when the Declination is South.

5. Draw the Line CF, parallel to W AE (downward when it's A.M. but upward if it be P.M.) to cut the *Primitive Circle* in F.

6. Lay the Magnetical Ampl. if $\left\{\begin{matrix}\text{A M.}\\ \text{P.M.}\end{matrix}\right\}$ from $\left\{\begin{matrix}\text{E}\\ \text{W}\end{matrix}\right\}$ to G, on the Primitive Circle, towards N if it be North ; but towards S, when it is South.

7. The Diſtance from G to N, laid (the ſame way) from F to *Falſe North*, which is now the North Point of the Compaſs, and it's done.

For the Diſtance from N to *Falſe North*, meaſured on the *Scale of Chords*, is the Variation Required.

To find the True Amplitude, the Proportion by *Chapter* 9. *Section* 2. *Problem* 4. in *page* 217. is thus ;

As S c. Latitude .. Radius : : S. ☉'s *Declinat* .. S. ☉ *Amplit.*
As S. 38d. 28m. .. S. 90d. : : S. 20d. 10m. N. .. S. 33.40 *North*

d. m. d. m.
True *Amplitude* EF 33.40. E.N. or NF 56.20 North Eaſterly
Magnetical —— EG 17.10 E.N. or NG 72.50 North Eaſterly
Subtract gives the Variation to be 16.30 Weſt.

Example 2. d. m.

The { *Latitude* ———— 40.50 } *North* }
{ *Sun's Declination* 10.19 } } *given* ; *Variat. Req.*
{ *Magnet. Amplitude* 15.10 *South* A.M. }

An

Anſw. The true Amplitude is 13d. 42m Eaſt Northerly, found by the foreſaid Proportion, by which the *Variation* is thus found.

d. m. d. m
True Amplitude EF 13.42 EN. or NF 76. 18 N. Eaſterly
Magnetical — EG 15.10 E S. or NG 105. 10 N. Eaſterly
Subtract, gives the *Variation* to be 28. 52 Weſt

The following Examples are for the Learner's Exerciſe, and are wrought by the foreſaid Directions and Rules.

Example 3. d. m.
The { *Latitude* —— 13 10 North
Sun's Declination 15 40 South
Magnet. Amplitude 9 12 S.P.M. } *given ; Variat. Requir'd.*

Anſw. According to the foreſaid Rules, it's as follows :

d. m. d. m.
True Amplit. WF 16. 06 W. S. or NF 106 06 N. Weſterly
Magnetical WG 9. 12 W. S. or NG 99 12 N. Weſterly
Subtract gives the Variation —— 6 54 Weſt.

Example 4. d. m.
The { *Latitude* —— 50 40 ——
Sun's Declination 19 50 ——
Magnet. Amplitude 5 15 P.M. } *South given ; Variat. Req.*

Anſw. The *Variation* is 25d. 47m. Weſt.

Example 5. d. m.
The { *Latitude* —— 21 30 ——
Sun's Declination 17 56 —— } North
Magnet. Amplit.—10 19 South P. M. } *given ; Variation Required.*

Anſw The *Variation* is 29d. 39m. Eaſt.

Example 6. d. m.
The { *Latitude* —— 25 30 South.
Sun's Declination — 18 12 North.
Magnet. Amplitude 9 50 S A.M } *given ; Variat. Req.*

Anſw. The *Variation* is 30d. 06m. Weſt.

Secondly, To find the *Variation* of the *Compaſs* by an *Azimuth*, obſerve theſe following *Definitions.*

1. *Magnetical Azimuth*, is an Arch of the *Horizon* contained between the *Sun's Azimuth Circle*, and the *Magnetical Meridian.* Or it's the apparent Diſtance of the Sun from the North, or South Point of the *Compaſs* ; and it's found by obſerving the Sun by the *Azimuth Compaſs*, either in the Forenoon or Afternoon, when he is about 5 or 10 Degrees high.

2. *Azimuth*, is an Arch of the *Horizon* contained between

the Azimuth Circle paſſing over the Sun, and the Meridian of the Place, which I call the *True Azimuth*, and is found by *Chapter* 9. *Section* 3. *Problem* 1. of *Aſtronomy*, in *pages* 229 and 230.

3. If the ſaid Azimuths agree; that is, if the *True Azimuth*, and *Magnetical Azimuth* agree, there is no Variation; but if they differ, their Difference is their Variation; which, rightly to account, obſerve this General Rule,

Reckon always both Azimuths (like as I ſaid for Amplitude in Page 253.) from the North.

In the Forenoon the { True —— / Magnetical } Azimuth greateſt, the Variation is { Eaſt / Weſt } But in the Afternoon it's { Weſt / Eaſt

Example 1. In the Forenoon, ſuppoſe the true Azimuth from the North to be 80 Deg. and the Magnetical Azimuth at the ſame time to be 101 Degrees, the Magnetical is the greateſt; and their Difference 21 Degrees is the Variation of the Compaſs Weſterly; but Eaſterly, had it been in the Afternoon.

Example 2. In the Afternoon let the true Azimuth be 115 Degrees, and the Magnetical Azimuth 101 Degrees, their Difference 14 Degrees is the Variation Weſterly; but Eaſterly had it been in the Forenoon.

Or thus, by the Rules following.

1. Always count both Azimuths from the North, in North Latitude; but from the South in South Latitude.
2. The leſſer Azimuth ſubtract from the greater, gives the Variation.
3. Placing both the Azimuths (before your Face) from you if the true Azimuth be to the Right hand of the Magnetical, the Variation is Eaſt. But if to the Left-hand the Variation is Weſt.

Theſe Rules will appear plain in the working the *Examples* of the next *Problem*.

Problem 2. *The Latitude of the Place, the Sun's Altitude, Sun's Declination, and his Magnetical Azimuth given, to find the Variation of the Compaſs.*

Example 1.			d m.	
The		Latitude ——	51 32 North	given: Variation required.
	Sun's	Altitude ——	11.30 A M.	
		Declination	15·10 North	
		Magn. Azim.	101·10 North	

To delineate the *Problem Orthographically*, *Plate* 9. *Fig.* 2.

1. Deſcribe a Circle, Quarter it, lay off the Latitude, draw the Equinoctial, Axis, and Parallel of Declination; in all reſpects as before directed (in *Problem* 1. in Page 254.) concerning an Amplitude.

2. By laying the Chord of the Sun's Altitude on the Primitive Circle from the Horizon SAN; draw the Parallel of Altitude parallel to the Horizon SAN; as the Line a C b, to cut the Parallel of Declination d C e, in C; the Place of the Sun at that time.

3. Draw C h parallel to WAE, downward when its A. M. but upwards if it be P M. till it meet an Arch (made with half the Parallel of Altitude) from the Center (of the Primitive Circle) A, and cutteth the ſaid Arch in h.

4. By A and h draw a Line, to cut the Primitive Circle in F; then NF, or SF, meaſured on the Scale of *Chords* ſheweth the Sun's true Azimuth.

5. Lay the Magnetical Azimuth (if $\left\{\begin{matrix}\text{North}\\ \text{South}\end{matrix}\right\}$ Latitude) from $\left\{\begin{matrix}\text{N.}\\ \text{S.}\end{matrix}\right\}$ (towards $\left\{\begin{matrix}\text{E.}\\ \text{W.}\end{matrix}\right\}$ when it is $\left\{\begin{matrix}\text{A.M.}\\ \text{P.M.}\end{matrix}\right\}$) to G on the Primitive Cir. But if $\left\{\begin{matrix}\text{PM}\\ \text{AM}\end{matrix}\right\}$ towards $\left\{\begin{matrix}\text{W}\\ \text{E}\end{matrix}\right\}$ to the ſaid G

6. The Diſtance from G to N, laid (the ſame Way) from F to Falſe North, which is now the North Point of the Compaſs, and it's done.

For the Diſtance from N to Falſe North, meaſured on the Scale of Chords, is the Variation of the Compaſs required.

Then to find the true Azimuth, the Proportion by *Chapter* 9. *Section* 3. *Problem* 1. in *Pages* 229 and 230. is thus,

d. m. d. m. d. m
90 00 90 00 90 00
Latitude ——— 51.32 N. ☉ *Alt.* 11.30 A.M. ☉ *Decl.* 15 10 N.
Compl Latitude 38.28 | *Comp.* ☉ *Alt.* 78.30 ☉ *diſt. fr. pole* 74 50
Compl Altitude 78.30 | *Radius* S.c. *Lat.* : : Sc. ☉ *Al.* ·· a 4th *Sine*
☉*s diſt. from pole* 74 50 | S. 90d. ·· S. 38.28 : : S 78.30 ·· S. 37.33
Sum is ——— 191 48 |
Then again,
The ½ *Sum is* ——— 95 54 | 4th *Sine* ·· S. ½ *Sum* · : S. *Rem.* ·· a 5th *Sine*
The Remainder is 21 04 | S. 37 33 ·· S. 95.54 : : S. 21 04 ·· S. 35.55

And againſt S. 35 55 on the Verſed Sines, is the
☉'s True Azimuth ——————— 80d. 02m North Eaſterly.
☉'s Magnetical Azimuth ——— 101d 10m. North Eaſterly.
Subtract giveth the Variation —— 21d. 08m. Weſt.

And for the Learner's *Practice*, take theſe following *Examples*, whoſe anſwers are found by the Rules foregoing.

Example 2. d. m.

The Latitude — 13 10 North
Sun's Altitude — 17 50 A. M.
Sun's Declination — 16 59 South
Sun's Magnet. Azim. 90 10 North
given: Variation required.

d m. d m. d m.
90.00 90.00 90.00
Latitude — 13.10N ⊙'s Altit 17.50 A.M ⊙'s Decl 16.59 S.
Comp. Latitude 76.50 *Comp. Alt.* 72.10 ⊙'s *diſt fr. Pole* 106.59

Comp. ⊙ *Altitude* 72.10
⊙*s diſt from pole* 106.59
Sum is — 255.59
The ½ *Sum* — 127.59
The Remainder is 21.00

Radius ·· S.c. *Lat.* :: Sc. ⊙'s *Al* ·· a 4th *Sine*
S. 90d. ·· S. 76.50 :: S. 72.10 ·· S 67.58
Then again,
4th *Sine* .. S. ½ *Sum* :: S. *Rem.* ·· a 5th *Sine*
S. 67.48 ·· S. 127.59 :: S. 21.00 ·· S. 17 45

And againſt S. 17.45 on the Verſed Sines, is the
⊙'s True Azimuth — 113d. 00m. North Eaſterly.
⊙'s Magnet. Azimuth — 90d. 10m. North Eaſterly.
Subtract giveth the Variation — 22d. 50m. Eaſt.

Example 3. d. m.

The Latitude — 28.40 North
Sun's Altitude — 20.19 P M.
Sun's Declination 19.12 South
Sun's Magnet. Azim 129.50 North
given: Variation required.

Anſwer. By the foreſaid Directions, the
⊙'s True Azimuth — 127d 02m N. Weſterly.
⊙'s Magnetical Azimuth — 129d. 50m. N. Weſterly
Subtract giveth the Variation — 2d. 48m. Eaſt.

Example 4. d. m.

The Latitude — 50 40 South
Sun's Altitude — 25 10 P. M.
Sun's Declination 23 30 South
Sun's Magn. Azim. 100.20 South
given Variation required

Anſwer. The Variation is 17d. 20m Weſt.

Example 5. d. m.

The Latitude — 23 10 South
Sun's Altitude — 10 15 A. M.
Sun's Declination — 23 30 North
Sun's Magn. Azim. 102 40 South
given: Variation required.

Anſwer. The Variation is 18d. 32m. Weſt

Example 6.

			d m.		
The	Latitude		37.45	South	given: Variation required.
	Sun's	Altitude	18.20	P. M.	
		Declination	20.15	North	
		Magnet. Azim.	115,40	South	

Anſwer. The Variation is 20d. 12m, Eaſt.

But the Variation may be found moſt readily by an Inſtrument called a *Rectifier*, whoſe Deſcription is as follows:

The Rectifier *deſcribed.* *Plate* 10.

This *Inſtrument* conſiſteth of two Parts, which are two *Circles* laid one upon another, and ſo faſtned together in their Centers, that they repreſent two Compaſſes, one fixed, the other moveable; each of them is divided into the 32 Points of the Compaſs, and 360 Degrees, and numbred both ways, from the North, and from the South; ending at the Eaſt, and Weſt, in 90 Degrees.

The *Fixed Compaſs*, repreſents the Horizon, in which the North, and all the Points of the Compaſſes are fixed, and immoveable.

The moveable One, repreſents the Mariners Compaſs Steered by, in which the North, and all other Points are liable to Variation.

In the Center of the moveable Compaſs, is faſtned a Silk Thread, long enough to reach the out ſide of the fixed Compaſs; But when it's made of Wood, there is an Index inſtead thereof: The Uſe is as follows.

1. *To find the Variation by the* Rectifier.

Note; Thoſe Degrees numbred from the North, and the South, towards the Eaſt, are termed the Right-hand; and the others towards the Weſt, are called the Left-hand.

Example 1. *At Sun riſing ſuppoſe the true Amplitude* 57d. *from the North, and the Magnetical* 73d. *What is the Variation of the Compaſs, and which way?*

Place 73d. (from the North) on the Right-hand in the moveable Compaſs, to 57d. (from the North) on the Right-hand in the Immoveable Compaſs; then the North Point of the Moveable Compaſs, will ſtand at 16d. of the Left-hand in the Immoveable Compaſs, which ſheweth the Variation of the Compaſs is 16 Degrees Weſt.

Example 2. *In the Afternoon, let the true Azimuth be* 80 *Degrees from the North, and the Magnetical* 101 deg. *What is the Variation of the Compaſs, and which Way?*

Place 101d. from the North: that is 79d. from the South on the Left-hand in the Moveable Compaſs, to 80 deg from the North, or Left-hand in the Immoveable Compaſs; then the North Point in the moveable Compaſs ſtands at 21 deg on the Right-hand in the Immoveable Compaſs, which ſhews the Variation of the Compaſs to be 21d Degrees Eaſt.

Always counting Amplitude at Sun-riſing, and Azimuth in the Forenoon, to the-right-hand, or towards the Eaſt; but at Sun ſetting, and in the Afternoon, count them to the Left-hand towards the Weſt.

2. *To Rectifie the Courſe by the* Rectifier.

This Propoſition hath two Caſes.

Caſe 1. The Variation of the Compaſs, and the Courſe ſteered, being given; to find the true Courſe.

Example 1. *Suppoſe the* Variation *be* 21 *Degrees Eaſt, and the Courſe ſteered by the* Compaſs *is N E. by N. I demand the true Courſe, the* Variation *being allowed.*

1. Place the N. Point of the Moveable Compaſs to 21d. from the North on the Right-hand, in the Immoveable Compaſs.

2. Lay the Thread or Index (which is faſtned in the Center) over the N. E. by N. Point in the Moveable Compaſs, keeping it ſtraight out; then in the Immoveable Compaſs the Thread or Index, will lie on 56 Degrees, or near N E. by E. which is the true Courſe required.

Example 2. *The* Variation 14 *deg. Weſt, and the Courſe by the Compaſs, E S E. I demand the Ships true Courſe.*

1. Place the North in the Moveable Compaſs, to 14 Deg. Weſt, in the Immoveable.

2. Stretch out the Thread, or Index, over E. S. E. in the Moveable, and it will lie on 82 Degrees in the Immoveable Compaſs, or E by S. ¼ E. the true Courſe required.

Caſe 2. *The* Variation *of the Compaſs and the true Courſe given; to find the Courſe by the Compaſs.*

Example. *The* Variation 21 *deg. Eaſt, and the true Courſe I ſhould ſteer is N E. by E. What Courſe muſt I ſteer by the Compaſs, to allow the* Variation?

1. Place the North, in the Moveable Compaſs to 21 Degrees Eaſt in the Immoveable Compaſs.

2. Stretch out the Thread over N E. by E. in the Immoveable Compaſs, and then in the Moveable Compaſs, it will lie on 35 Degrees, or near N E by N. the Courſe you muſt ſteer to allow for the Variation of the Compaſs.

Here I thought to deſcribe the Azimuth Compaſs, and how to obſerve by it; but conſidering it's an Inſtrument eaſily underſtood, that Diſcourſe may be ſpared.

CHAP. XI. *Of an* Obſervation. *either of Sun, or Star, what it is, how, or with what, and when 'tis taken, and finding the* Latitude *thereby.*

1. AN *Obſervation*, is the finding either the Sun's, or Star's Meridian Altitude (at Sea) with a Quadrant, or with a Croſs-ſtaff.

2. Meridian Altitude, is the Height above the Horizon of the Sun or Star, they being upon the Meridian of the Place of Obſervation; and that the Sun is every Day at Noon, but the Star's at different Times, according to the differing of their ſeveral Right Aſcenſions from the Sun's Right Aſcenſion.

3. A Quadrant is an Inſtrument whereby the Sun's Altitude (only at Sea) is found.

4. A Croſs-ſtaff or Fore-ſtaff, is an Inſtrument whereby Mariners find either the Sun, or Star's Altitude. The particular Deſcription of theſe Inſtruments I here omit, having done it largely in the *Mariners Compaſs Rectified*; to which Book I refer the Learner, and will now ſhew how to find the Latitude after you have Obſerved, which is called, working an Obſervation, and that in this one Propoſition.

Propoſition. *The Meridian Altitude of any Heavenly Object, and its Declination given; to find the Latitude of the Place of Obſervation.*

In this Propoſition are two Caſes.

Caſe 1. *Where, or when the Object obſerved doth both Riſe and Set in 24 Hours, The Rules are theſe.*

Rule 1. The Meridian Altitude, and Declination of one kind; that is, both North, or both South; the Difference of the Zenith Diſtance, and the Declination, is the Lat. required.

Note, When the Declination is greater than the Zenith Diſtance, the Latitude is of the ſame Name; but if leſs, then of a contrary Name to the Declination.

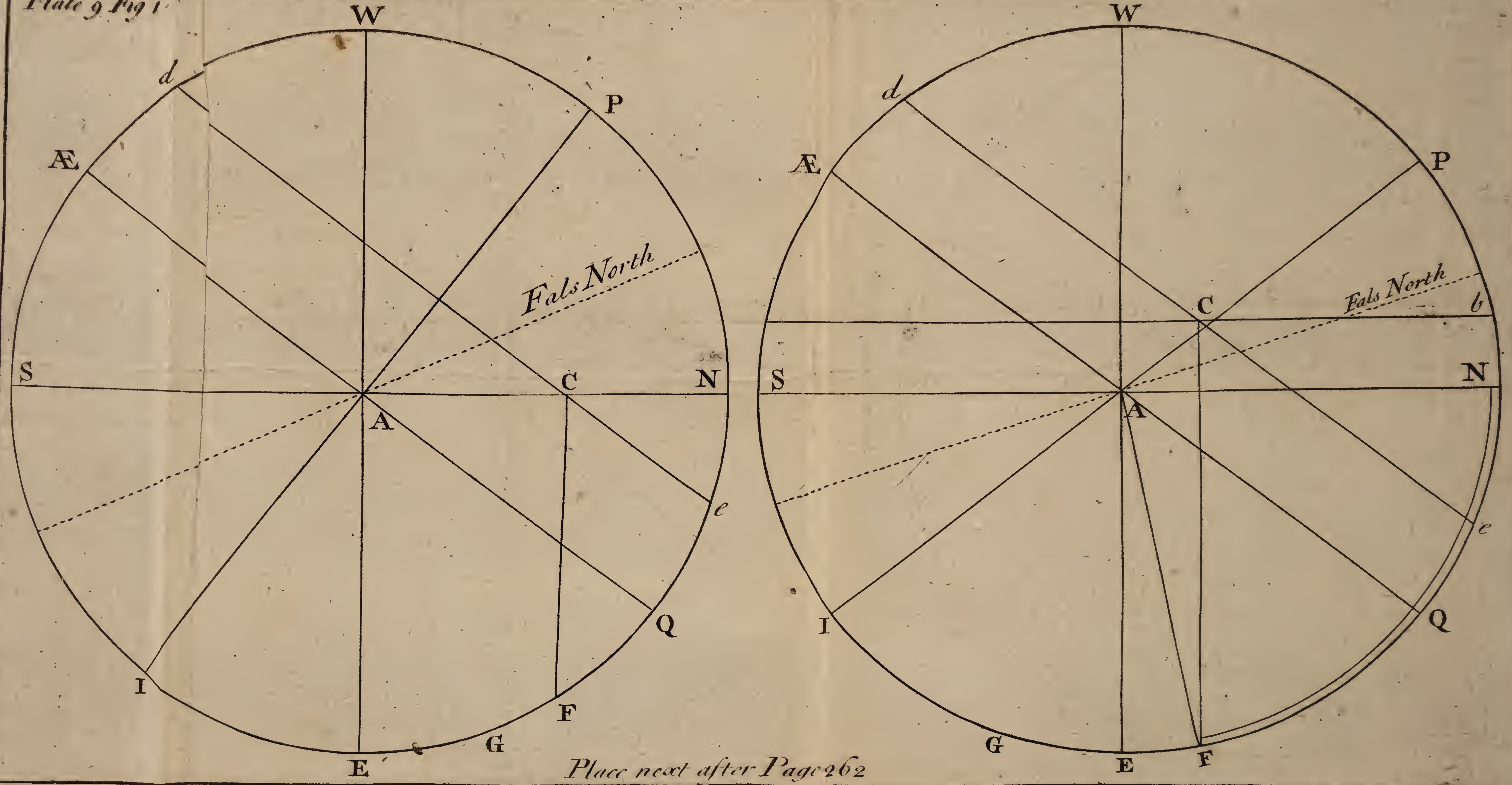
Rule 2. The Meridian Altitude and Declination of contrary Names; that is, one North, and the other South, The Sum of the Zenith Diſtance, and the Declination, is the Latitude required, of the ſame Name with the Declination.

Note 1. By Meridian Altitude South, I mean the Object obſerved is to the Southward of the Obſerver; and when North, then to the Northward of the Obſerver.

Note 2. By Zenith Diſtance, underſtand the Complement of the Meridian Altitude of object obſerved.

Example 1. On the 20th of *May* 1731. the Sun's Meridian

Plate 9 Fig 1



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Altitude 61 d. 08m. South; and his Declination 21d. 54m. North, What is the Latitude of the Place of Obſervation?

d, m,
The Sun's Zenith Diſtance —— —— —— 28 52 South
Sun's Declination —— —— —— —— 21 54 North
The Sum (by *Rule* 2.) is Latit. required —— 50 46 North

Example 2. On the 1ſt of *July* 1731. the Sun's Zenith Diſtance being 11d. 50m. North, and his Declination 22d. 04m. North. What is the Latitude of the Place of Obſervation?

d. m.
From the Sun's Declination —— —— 22 58 North
Subtract the Sun's Zenith Diſtance —— 11 50 North
The Remainder is the Latitude required —— 11 08 North

Example 3. On the 3d of *June*, 1731, the Sun's Zenith Diſtance being 29d 15m South, and his Declination then 23d. 17m. North. What is the Lat, of the Place of Obſervation?

d. m.
To the Sun's Zenith Diſtance —— —— 29 15 South
Add his Declination —— —— —— 23 17 North
The Sum (by *Rule* 2.) is the Latit. required 52 32 North

Example 4. On the 20th of *March* 1731, the Star *Fomelhaut* being obſerved, and his Zenith Diſtance 20d 17m. North, this Stars Declination (in *Page* 178) is 31d. 19m. South. What is the Latitude of the Place of Obſervation.

d. m.
To the Stars Zenith Diſtance —— —— 20 17 North
Add the Star's Declination —— —— 31 19 South
The Sum is the Latitude required —— 51 36 South

Example 5 The 30th of *March* 1731. the Foot of the *Croſiers* (by ſome called the *Cock's Foot*) a Star much uſed in Southern Voyages, being obſerved, his Meridian Altitude was 48d. 06m South; this Star's Declination (in *page* 178) is 61d. 15m. South. What is the Latitude of the Place of Obſervation?

d. m.
From the *Croſiers* Declination —— —— 61 15 South
Subtract his Zenith Diſtance —— —— 41 54 South
The Remainder is the Latitude required —— 19 21 South

Caſe 2. *Where, or when the Object obſerved doth neither Riſe nor Set in 24 Hours; that is, doth not in the Diurnal Motion, move below or under the Horizon.*

Note 1. In ſome parts of this Earthly World, both the Sun and Stars do not Riſe nor Set, but are above the Horizon, and upon the Meridian of the ſame Place twice in the ſpace of 24 Hours; and this laſteth but for ſome part of the Year with the Sun, but always with ſome Stars.

Note 2. Where the Sun, or a Star, doth neither Riſe nor Set; it cometh upon the Meridian below or under the Pole; and then it's at the leaſt Meridian Altitude.

Note 3. Some Stars in ſome Places come upon the Meridian both below and alſo above the Pole; that is between the Zenith and the Pole; and then it's at the greateſt Meridian Altitude.

Note 4. Where a Star cometh upon the Meridian both below, and alſo above the Pole, it's always to the Northward, both in its leaſt and greateſt Meridian Altitude, or elſe always to the Southward,

Note 5. Again there are ſome Stars come upon the Meridian to the Northward, and below the Pole; and to the Southward between the Zenith and the Equinoctial; and alſo to the Southward, and below the Pole; and to the Northward between the Zenith and the Equinoctial.

Note 6. Where the Sun cometh to the Meridian below, or a Star, both above and below the Pole, the Latitude of that place is of the ſame Name, with the Sun, or Stars Declination: That is, if the Sun or Star's Declination be North, the Latitude of the Place is North; but South, when the Declination is South.

Note 7. For thoſe Stars which never come (the Sun never doth come) to the Meridian above the Pole, at their greateſt Meridian Altitude, the former two Rules ſerveth for to find the Latitude.

Then to find the Latitude by the Sun under the Pole, or Star's both under and above the Pole. The Rules are theſe.

Rule 3. The Object obſerved, being on the Meridian below the Pole, the Sum of the Meridian Altitude, and Complement of the Declination, is the Latitude required, of the ſame Name with the Declination.

Rule 4. The Object obſerved, being on the Meridian above the Pole, the Difference of the Meridian Altitude, and the Complement of the Declination is the Latitude required, of the ſame Name with the Declination.

Example 1. *Auguſt* 1ſt, 1731. the Sun's Meridian Altitude below the Pole, or under the Pole, was found to be 5d 30m. and his Declination 8d. 37m. North; What is the Latitude of the Place of Obſervation?

	d. m.	
To the Complement of the Sun's Declination	81 23	North
Add his Meridian Altitude below the Pole	5 30	
The Sum (by *Rule* 3) is the Latitude	86 33	North

Example 2. On *December* the 8th, 1731, the *Bull's Eye Aldebaran* came upon the Meridian under the Pole, and his Meridian Altitude was obſerved to be 9d. 10m. this Star's Declination (in *Page* 178) is 15d. 50m. North; What is the Latitude of the Place of Obſervation?

	d m.	
To the Complement *Bull's Eye* Declination	74 10	North
Add his Meridian Altitude under the Pole	09 10	
The Sum (by *Rule* 3.) is the Latitude	83 20	North

Example 3. On *June* the 25th 1731, the Foot of the *Croſiers* was obſerved under the Pole, its Meridian Altitude 21d. 25m the Declination of this Star (in *Page* 178) is 61d 15m. South: I demand the Latitude of the Place of Obſervation?

	d m.	
To the Complement of the Star's Declination	29 45	South
Add his Meridian Altitude	21 25	
The Sum (by *Rule* 3) is the Latitude	51 10	South

Example 4. The 17th of *February*, 1731, the *Northern Pointer* of the *Great Bear* came to the Meridian above the Pole, and his Meridian Altitude was 56d 10m. this Stars Declinatian is 63d. 30m. North: What is the Latitude of the Place of the Obſerver?

	d m.	
From the Star's Meridian Altit. above the Pole	56 10	
Subtract the Complement of his Declination	26 30	North
Remainder (by *Rule* 4) is the Latitude	29 40	North

Chap. XII. *A Sea-Rickoning, or Journal, what it is, and the manner how it's kept, Directions to Correct it, with an Example, and the Explanation thereof.*

THE keeping a good *Reckoning* or *Journal*, is not only the *Mariner's* Reputation, but (under God) the Preſervation of a Ship, and all in it; the Ignorance thereof has been, (if not the Only, I may ſay) the chief Cauſe of loſing divers Rich Ships, and many Dear Lives, and thence the impoveriſhing of ſeveral Famalies.

Then certainly, it ſhould be their great Concern, to be expert herein, who take on them the *Navigating Ships* to remote Places, when ſo great a Truſt as Men's Lives and Eſtates are repoſed in them, that ſo, by a knowledge of, and a conſtant careful Practice, in keeping an exact *Journal*, they may not only bear the empty Name of *Navigator*, but thereby prove themſelves deſervedly worthy of the Title of *Compleat Artiſts.*

And for a Compleat keeping a *Journal*, I prefer this Method hereafter following; which tho' it be new, and uſed (as I know of) but by few, yet I doubt not, when better known, it will be more uſed: Now that you may rightly underſtand what it is, and how to keep an Account of the Ships Way by this new Form, I will thus explain it.

I Know that a *Journal*, or Sea-Reckoning, is a punctual writing down every Day in a Book (fit for that purpoſe) the Courſe, Diſtance, Difference of Latitude, and Departure the Ship hath made what Latitude and Longitude ſhe is in; and alſo the Wind, Weather, with all Accidents and Occurences that happen.

To perform which after the beſt manner, do theſe preparative Things.

Firſt, Provide a Folio Book of 2, 3, or 4 Quire of Demy-Paper, and let it be rul'd like the *Log-Board*, (in *Page* 65) with 5 Columns, taking up about half the breadth of each Page.

Theſe five Columns may be marked or noted at the Head of each Column, with Letters thus;

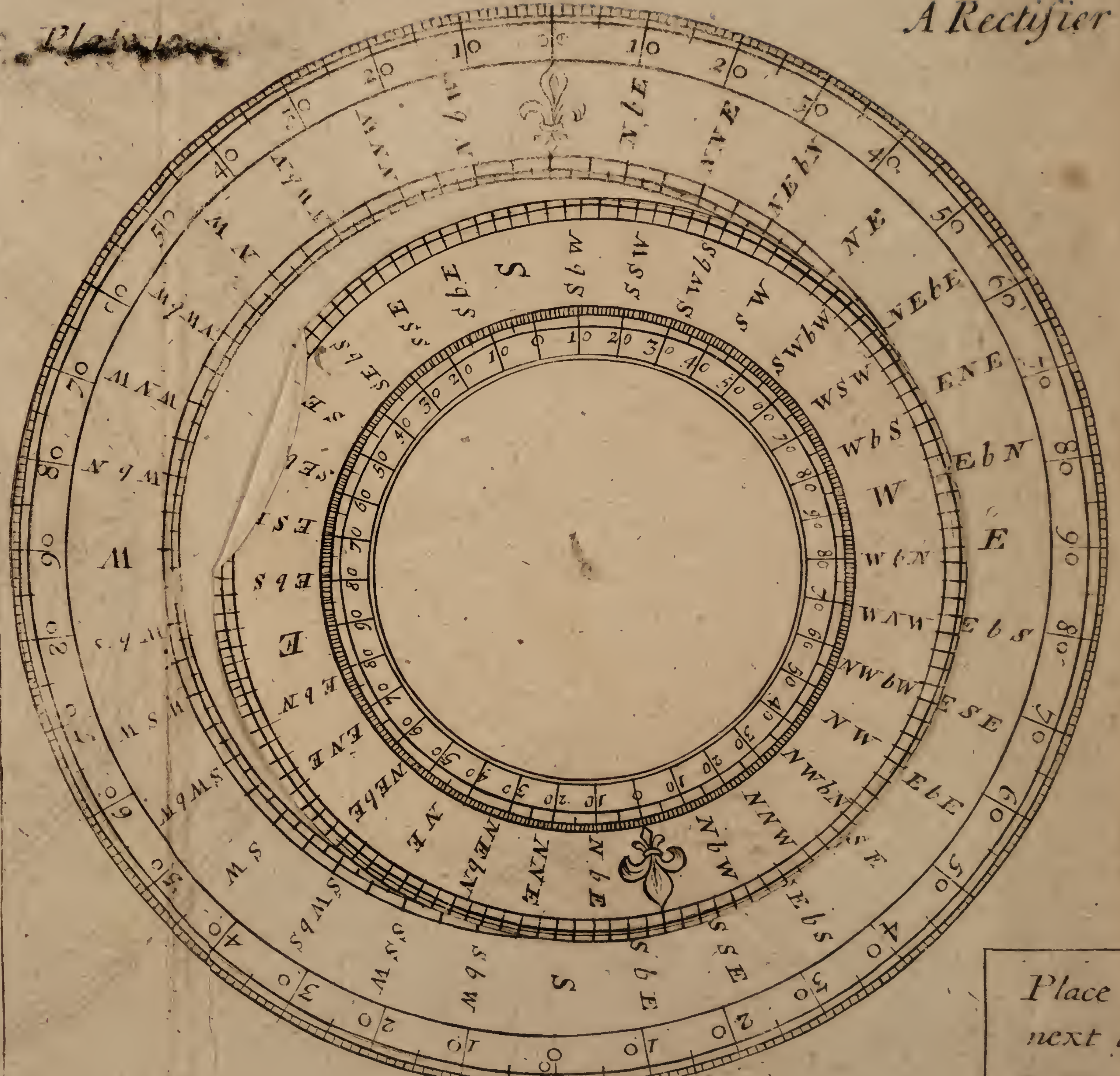
H } which ſtandeth for { *Hours* under it are the Hours of the Day
K } which ſtandeth for { *Knots,* } run out that Day.
F } which ſtandeth for { *fathoms* } run out that Day.
C } which ſtandeth for { *Courſes*, which have been ſteered that Day.
W } which ſtandeth for { *Winds*, which have blown that Day, *&c.*

Secondly, Rule 12 Lines croſs the foreſaid 5 Columns, and ſo far aſunder, that on Occaſion you may write two Lines of writing in the Spaces between thoſe Lines; then will the ſame Ruling ſerve for an *Eaſt India Voyage*, in which the *Log* is heaved out every Hour, and alſo for other Voyages where it's uſed every two Hours.

Thirdly,

Plate [illegible]

A Rectifier



Place this
next after
page 266

Thirdly, In the firſt Column (marked at the upper end with H) write down the Hours of the Day; that is for Common Voyages, 2, 4, 6, 8, 10, 12, and 2, 4, 6, 8 10 and 12: But for an *Eaſt India* Voyage, 1, 2, 3, *&c.* to 12 at Midnight; then 1, 2, 3, *&c.* to 12 at Noon. And thus far is the Book fitted, and prepared to coppy off the *Log-Board.*

Fourthly, Under theſe 5 Columns let there be ruled 12 ſhort Columns, which may take up the whole Breadth of each Page of the Book. Theſe may be entituled as in the Journal following this Diſcourſe, (in Pages 274 and 275) and needs not any farther Explanation.

Now ſuch a Book ſo Ruled as here expreſs'd, each Page thereof will contain two Days Sailing, with all appertaining thereunto as ſhall afterwards appear.

Fifthly, Having a *Journal Book*, thus prepared, and now on your departing, the firſt thing is to enter the Title of the *Journal*, which may be done thus: In the Top or Head of the firſt Page of the *Journal Book* write the Title thereof in Words after the Form immediately before the *Journal*, in Page 273.

And now the Book is compleatly prepar'd, fit for the Uſe intended, and that's keeping a *Sea Reckoning*, after this manner.

2. Next under, or after the Title, (write in the Blank Space between the 5th Column for the Wind, and the Side of the Book) the *Year*, *Month*, *Day* and *Hour*, you part with ſight of the Land, and alſo the Circumſtances and Actions attending the ſame, *&c.* as here you may ſee in the two firſt Sides of the *Journal*: which by reaſon of the ſmallneſs of this Book reacheth Pages 274 and 275, which are to be eſteemed but as one Page, or Side of the *Journal.*

3. Every Day at Noon, write in the 5 Columns the ſame you find writen on the *Log-Board*, which containeth the *Ship's Courſes Steered*, *Diſtances* run by the *Log*, what Winds have blown, what *Sails handed*, and when.

4. In the Vacant Space of the Right-hand of theſe 5 Columns (which takes up more than half the Breadth of the Book) expreſs the Tranſactions of that Day, as *Winds*, *Weather*, *Currents*, *ſetting of the Sea*, *handing of Sails*, *meeting or parting with Ships*, *Death of Men*, *Variation of the Compaſs*, and all other *Accidents* and *Occurrences* whatſoever.

5. Then Correct the ſeveral Courſes, by allowing for *Leewardway*, *Currents*, and *Variation*, according to the Nature of

them; and bring them into one Courſe (by *Chapter* 3. *Section* 4. of *Plain Sailing*, in *Page* 64.) by which you will find the Ship's *Diſtance*, *Difference of Latitude*, and *Departure* from the Meridian; which being ſet down in the Columns bearing thoſe Titles, then (by *Chapter* 3. *Section* 3. *General Rule* 3. in *page* 58) find the *Latitude* the Ship is in, and ſet that in its proper Column: And laſtly, (by *Chapter* 4. *Section* 3. *Problem* 5. in Pages 96 and 97. Alſo *Chapter* 4. *Section* 2. *Problem* 5. Page 91 of *Mercator's Sailing*) find the Longitude the Ship is in, and place that in the 12th and laſt Column; and thus you finiſh that Days Work.

For *Leeward*, or *Leeway*, the Allowances are ſuch as in theſe 8 Caſes following.

Firſt, The Ship being upon a Wind, allow one Point for *Leeway*.

Secondly, The Wind blowing hard to cauſe one *Topſail* to be taken in; allow two Points for *Leeway*.

Thirdly, When it blows ſo hard, that both *Top ſails* are taken in, and the Sea runs high; allow then three Points for *Leeway*.

Fourthly, The *Fore-ſail* being furl'd, and the Ship *Try* under a *Main-ſail*, and a *Miſſion*; allow four Points for *Leeway*, for ſhe then makes her way about four Points before the *Beam* (as the Sea Phraſe is.)

Fifthly, When the *Ship Trys* under a *Main-ſail* only, ſhe then makes her way near three Points before the *Beam*; that is, near Five Points for *Leeway*.

Sixthly, If the Ship trys under a *Miſſion* only, her Way is about two Points before the *Beam*; that is, allow ſix Points for *Leeway*.

Seventhly, When ſhe *Lies a Hull*; that is, with all her Sails Furl'd, her way is one Point before the *Beam*, and then ſeven Points is her *Leeway*.

Eighthly, If the Wind hath blown hard at W.S.W. and made the *Sea* run high, the *Ship* ſtemming South, and the Wind ſhifting to E S E. then whilſt the Sea continues to run high, it ſtrikes the Ship on the *Lee Bow*, and abates the *Leeway*.

Note; In all thoſe eight Caſes, reſpect muſt be had to the ſmoothneſs of the Water, or the *Sea's running high*, and then the Allowances may be rectified with the greater Certainty, by ſetting the *Ship's Wake* by the *Quarter of the Compaſs*, placed on each Rail of the *Ships Quarter*, which is uſually ſet there for that Purpoſe.

Theſe Directions, with a Conſideration of the *Ship's Trim*

Sail aboard, *Streſs of Wind*, and growth of the *Sea*, being put into Practice, will ſo improve the *Young Navigator*'s Judgment, that he'll ſeldom fail of making a true Allowance for the Ship's Leeway.

6. After this manner are you to proceed every Day from *Noon* to *Noon*, which is the beginning and ending of the Day Aſtronomical, the Day by which the *Mariners* keep their Sea-Reckoning.

7. Remembring always to obſerve for the Latitude, when Opportunity preſents, either by *Sun* or *Stars* ; that being the chief thing to be depended on, and by which the Reckoning is confirmed or rectified, which is the next thing to be treated of.

8. When the Latitude by Account agrees with the Latitude by Obſervation, then is the Reckoning confirmed, and you are ſure it's kept well.

9. But if they diſagree, then either the Ship hath out-run your Reckoning, or your Reckoning hath out run the Ship; and there is ſome Error, either in the Courſe, Diſtance ſailed, or both of them ; Now, to find where the Error lies conſider whether there be a Current, or no.

10. If there be a *Current*, try it, and find which way it ſets, and how faſt; and by that Correct both Courſe and Diſtance; and if that makes the *Reckoning Latitude* to agree with the *Obſerved Latitude*, you have then truly Corrected the *Reckoning*.

But if you, only by ſome probable Reaſon, conjecture there is a *Current*, then give what Allowance you think meet to the *Difference of Latitude*, and *Departure*, and ſee if that will reform your *Reckoning Latitude*, that it agree with the obſerved Latitude; if ſo you have gueſſed well (for you muſt ever keep to the *Latitude* by *Obſervation* that being the principal thing to be relied upon) but if it will not agree with the *Obſerved Latitude*, it's to be ſuppoſed that there are miſtakes in your *Conjecture*, or ſome other Cauſe of this *Error* in the Reckoning.

11. When there's no *Current*, nor any *Variation*, or if there be either or both ; and they are allowed for according to Art and Reaſon, and yet they will not agree with the *Obſerved Latitude*; then there is an *Error* either in *Steerage*, or in the *Log*, and to know in which it is, take this

General Rule.

Differ. of Latitude }	the greater, the *Error* is in the	{ *Log.*
Departure ——— }		{ *Courſe.*

12. When there is an *Error* in the Courſe ſteered, you muſt (after the Allowance in the 10th and 11th Rules have been

made) then only correct the Difference of Latitude and ſo make the *Reckoning Latitude* to agree with the *Latitude* by *Obſervation*, and the Work is done.

13. But when the *Error* lieth in the *Log*, the Diſtance is faulty, and this is that which moſt uſually makes the Difference between the Obſerved Latitude, and the Latitude Reckoning. And herein are two Caſes.

Caſe 1. *In North Latitude ſailing towards the North, and in South Latitude, ſailing towards the South.*

If the Obſerved Latitude be the greater, then hath the Ship out-run the Reckoning; but if it be the leſſer, the Reckoning hath out-run the Ship.

Caſe 2. *In North Latitude, ſailing towards the South, and in South Latitude, ſailing towards the North.*

If the Obſerved Latitude be greater, then hath the Reckoning out-run the Ship; but if it be the leſſer, the Ship hath out-run the Reckoning.

14. When the Ship hath out-run the Reckoning, then is the Reckoning too little, and the Difference between the obſerved Latitude and Reckoning Latitude, muſt be added to the *North* or *South Column* in the Reckoning; and ſo doing it'sCorrected.

15. But when the Reckoning hath out run the Ship, then is the Reckonging too great, and the Difference between the Obſerved Latitude and Reckoning Latitude, muſt be ſubtracted from the North, or South Columns in the Reckoning; and ſo doing it's Corrected.

16. To Correct the Departure (the Eaſt, or Weſt Column in the Reckoning) when the Error is in the Diſtance do thus: Add up the N, S, E, and Weſt Columns from the beginning, if it be the firſt Error; otherwiſe from the laſt Error, or from the laſt Obſervation to the Day of the preſent Error; in order to find the Difference of Latitude and Departure; as was ſhewed in adding up the Columns in a Traverſe.

And then the Proportion to find the Error, or Correction in the Departure, is this;

As the Difference of Latitude, is to the Departure;
So is the *Correction* in Latitude to the *Correction* in Departure.

Note; Correction in Latitude is the Difference between the Obſerved Latitude, and Reckoning Latitude.

The Correction in Departure muſt be added to, or ſubtracted from the Eaſt or Weſt Column in the Reckoning, according to the 14th and 15th Rule aforeſaid; and ſo the Departure will be Corrected.

17. To Correct the Longitude do thus; Find (by the *Table of Meridional Parts*) the Meridional Difference of Latitude, between the Obſerved Latitude, and the Reckoning Latitude, and then the Proportion is this:

As the *Correction in Latitude, is to the Correction in Departure:*

So is the *Meridional Difference of Latitude*, to the *Correction in Longitude.*

Then according to the new Way of Computation of Longitude in the *Mariners Compaſs Rectified*, if the Longitude, and its Correction be both Eaſt, or both Weſt, add; but one Eaſt, and the other Weſt, ſubtract, and the Longitude is Corrected.

And having gone over the *Rules*, and *Directions* about keeping, and Correcting a *Sea-Reckoning, or Journal*; I will alſo give an *Example* of a *Journal*, of an intended *Voyage* from the *Lizard* towards *Barbadoes*, that the foregoing Rules may be the better underſtood.

And altho' this following *Journal* be but an *Example* of Seven Days, (being ſo deſigned that this Book might not ſwell too big (yet it may be of ſufficient Intelligence to a diligent Reader) for the right underſtanding this Method of *Keeping, and Correcting a Sea Journal*; eſpecially if the following *Explanation* be deliberately compared with the preceeding Directions; and thereby as informing, as if the whole Series of the *Voyage* had been inſerted, which would have both augmented the Book, and its Price, but not anſwerably the underſtanding it.

Having been treating about *Keeping* and *Correcting*, a *Journal*, which cannot well be done 'till the *Error* in the *Log-Line* and *Half-Minute-Glaſs*, be Rectified; I think it neceſſary here to ſay ſomething of both.

The manner of keeping a *Reckoning* or *Sea-Journal* (by our *Engliſh Navigators*) is by the *Log-line*, and *Half-Minute-Glaſs*; Ought not care to be taken that they be true, elſe a Reckoning kept by them cannot be true?

But it hath been an ancient Cuſtom, and ſtill is too much uſed, to meaſure 7 Fathom, or 42 Feet, between Knot and Knot on the *Log-Line*, which is grounded on this Conjecture; That 5 Feet makes a Pace, a 1000 (ſuch) Paces a Mile, and 60 (ſuch Miles) makes a Degree; that is a Degree contains 300000

Feet, and a Mile (or Minute) 5000 Feet; and becauſe an *Half-Minute* of Time is the 120th part of an Hour, and the 120th part of (a Mile) 5000 Feet, is almoſt 42 Feet, the Meaſure commonly put between each Knot on the Log-Line.

But this Erronius Computation hath been ſufficiently contradicted by Mr *Oughtred*, Mr *Norwood*, and others.

Mr. *Oughtred*, in his *Circles of Proportion*, in Page 153, doth allow 66¾ *Statute Miles* to a Degree on the Earth, each Mile being 5280 Feet, ſo that in a Degree there are 349,800 Feet.

And Mr. *Richard Norwood* in his *Seaman's Practice*, Page 43, doth prove a Degree on the Earth, to contain 367200 *Engliſh* Feet: but at length conſents to allow 360000 Feet to a Degree. and ſo 6000 Feet the 60th part, to be one Minute, commonly called a Mile; ſo that 6000 Feet ſhould be the Number from whence the Knots on the *Log-line*, ought to be deduced.

Therefore, if 6000 (the Feet in a Mile or Minute) be divided by 120 (the Half Minutes in one Hour) the Quotient is 50 Feet; for the Diſtance of each Knot, on the Log-line, and 25 Feet is half a Knot.

Now 5 being the one Tenth of 50, let each fathom on the Log-line contain 5 Feet; and then 5 of theſe fathoms make a Half Knot, and 10 of them one Knot.

And According to theſe Meaſures, let every Man that would keep a true Reckoning, and give a good Account of his Voyage, be perſwaded to mark his Log-Line, and not let cuſtom prevail above Reaſon.

Then it follows, That if a Ship runneth out one of theſe Knots in half a Minute, ſhe runneth one Mile or Minute, the 60th part of a Degree in an Hour; if 2 Knots, then 2 Miles; if 3 Knots and 4 Fathoms, then Miles 3.4; that is 3 Miles and 4 Tenths of a Mile in an Hour, and ſo for any other. And by ſuch a Log-Line is the following Reckoning kept.

The like regard muſt be had, that the Half Minute-Glaſs be of a juſt Length, otherwiſe no true Account of the Ship's Way can be kept: Now for that, take an approv'd Experiment, mentioned by Mr *Philips*, in his *Advancement of Navigation*, the Second Part, Page 9. as follows.

An eaſy and exact way to Meaſure a Half-Minute-Glaſs.

Let a *Plummet* of any form or weight, be faſtned to one end of a *Thread*, or *Silk-ſtring* that is 38½ Inches long, and at the other end is a Loop or Nooſe, to hang it on a ſmall Pin or Nail, faſtned in any Place, ſo that the Plummet may ſwing freely.

Then the Loop of the *String* being hung on the Pin, the *ſtring* 38½ Inches from the Center of Gravity to the Center of Motion; this is 38½ Inches from the end of the Loop, to the middle of the *Plummet*; and the *Plummet* cauſed to Swing; each of thoſe *Swings* ſhall be a true Second of Time, and 30 of them the juſt Length of an *Half-Minute Glaſs*.

Always counting the *Swings* both forward from, and backward to the Perpendicular, ſuppoſed to fall from the Pin whereon the String doth hang: For half a Second of Time is meaſured every time the Plummet paſſeth from the Perpendicular, to its utmoſt Swing eitherways.

But when the Ship hath any conſiderable Motion, make the String 7 Inches ſhorter, and there make a Knot to hold it by, between your Finger and Thumb; then by the Motion of the Hand, cauſe the Plummet to aſcend to an Angle of about 60 Degrees, every Swing from the foreſaid Perpendicular; then each Swing ſhall be equal to thoſe before mentioned; So that by this Experiment, you may meaſure a true *Half Minute of Time* without a *Glaſs*, and by it examine the Truth of any *Glaſs*.

A Journal of a VOYAGE

(By God's Permiſſion) in the
George of LONDON. *A. B.* Commander.

FROM THE

Lizard in { *Latitude* 50d. 00m North.
Longitude 5d. 24m Weſt.

TO THE

Iſland Barbadoes in { *Latitude* 13d 25m. North.
Longitude 58d. 04m. North.

Their Difference of Longitude 52*d.* 40*m.* Weſt.
The Courſe from the *Lizard*, South 49*d* 55*m*. *Weſt*
Their Diſtance in that Rhomb, 3407 *Minutes*.
Kept by *C. D.* Chief Mate

Began *January* ☉ 16*th*, 1722

	H	K	F of 5 Feet	C	Wind and Weather
Afternoon	2	5	2	W by N	N N E.
	4	5		W S W	N. *Silly* N by W 7 Leag. off
	6	5	6		N N E.
	8	5	5		
	10	5	5	SW by W	N W by N. *Rain*
	12	6	5	W S W	North *Rain*
After Midnight	2	6	1		N by E.
	4	6	1		
	6	6	3		N E. by N. *Rain*
	8	6		SW by W	
	10	6		W S W	
	12	6			E N E.

ſum'd up 69 ——— 8 ——— Which doubled, (is Min. 139·6

Month Days	*Week Days*	*Month and Year*	*Courſe*	*Diſtance ſailed in Minutes*	*Diff. of Lat. in Min.* N	*Diff. of Lat. in Min.* S
16	☽	Jan. 1718	S	18		m. 18.0
17	♂		WSW.	137		91.5

☽ The 16 of *January*, 1732. At Noon we ſaw the *Lizard* Point bear North about 18 Minutes or Miles Diſtance off us: We had variable Winds, freſh Gales, cloſe hazy rainy Weather, as *per Columns*.

In Company with the *Succeſs*, Capt. *E. F.* Commander, bound for the *Eaſt-Indies*.

♂ 17th our *Courſe* and *Diſtance* made good this Day, I make W S W. 137 Minutes, with Latitude, Meridional Diſtance, and Longitude: as *per Columns* underneath.

d. m. d. m.
Zenith Diſtance —— —— *Magnet Amplitude* —— 27 30 E S.
Declination —— —— *True Amplitude* —— 39 55 E S.

Lat. by Obſ. —— —— *Variation* —— —— 12 25 W.

Depart. in Min.		*Latitude by Account in deg. and min.*	*Meridional Diſtance deg. and min.*	*Longitude by Account in deg. and min.*
E	W			
		49.42 North		05.24 W.
	m127.3	48.51 North	02.07 W	08.37 W.

	H	K	F of 5 Feet	C	Wind and Weather
Afternoon.	2	6	—	W S W	N E *Rain and Snow*
	4	6	—	S W	
	6	5	8		*Rain and Snow*
	8	7	1	SW by W	N E by E. *Rain*
	10	7	—	W S W	E N E *Rain*
	12	7	1		N E by N *Rain*
After Midnight	2	7	—		N E *Lightning*
	4	6	8	SW by W	N E by E
	6	7	2	W S W	N E
	8	7	—		E N E *Hail and Rain*
	10	6	2		*Rain*
	12	6	6		E. *Rain*
Sum is		79	8		Which doubled (is Min. 159,6

Month Days	*Week Days*	*Month and Year*	*Courſe*	*Diſtance ſailed in Minutes*	*Diff. of Lat. in Min.* N	S
18	♂	Jan. 1732	*swbw½w*	158		73.6

♂ The 18th of *January*, 1732, hard *Gales* of variable Winds, with ſome Snow, *Hail* and *Rain.*

Our Top-ſails Reef'd, and ſo have been ever ſince we ſaw the *Lizard.* A great ſwelling Sea following us, and ſetting towards the SSW.

Our *Courſe* and *Diſtance* I judge to be SW by W. ½ Weſt 158 Minutes, with Latitude, Meridional Diſtance and Longitude as in the *Columns* underneath.

	d. m.		d. m
Zenith Diſtance	——	*Magnet Ampl*	——
Declination	——	*True Ampl.*	——
Lat. by Obſervation	——	*Variation*	——

Depart. in Min.		*Latitude by Account in deg. and min.*	*Meridional Diſtance in deg. and min.*	*Longitude by Account in deg. and min.*
E	W			
	m139 8	47.37 North	04 27 W	12.10 W.

	H	K	F of 5 Feet	C	Wind and Weather.
Afternoon	2	6	3	S W by W.	E. *Hail* and *Rain*
	4	7	3	S W.	*Handed Fore-Top-Sail* *Rain*
	6	8	—		N E. *Rain*
	8	7	6		
	10	8	2		
	12	8	—		
After Midnight	2	8	—		
	4	8	—		
	6	8	—		*Rain*
	8	8	1		*Handed Main-Top-Sail.* *Rain*
	10	6	7		
	12	6	2		

ſum'd up 90 — 4 Which doubled, (is Min. 180 8

Month Days	*Week Days*	*Month and Year*	*Courſe.*	*Diſtance ſailed in Minutes*	*Diff of Lat in min* N.	S.
19	♃	Jan. 1732 45d. 07m.	S W.	181		125.29
		Correction by Obſervation			—	24.0
		Corrected.				149.9

♃ The 29th of *January*, 1732, was bad *Weather*, very hard *Gales*, *thick Air*, with ſome *Hail* and *Rain.*

A great Sea after us, ſetting towards the SSW. for theſe three Days paſt.

By *Obſervation* the Ship hath out-run the Reckoning 24 Minutes South, which being attributed to the SSW. Sea, our *Courſe* and *Diſtance* corrected is S W. by S. ¾ W. 204 Minutes; with *Meridional Diſtance*, and *Longitude*; as underneath.

	d m.		d. m.
Zenith Diſtance	62 55 S.	*Magnet. Amp.*	37 00 W S.
Sun's Declination	17 48 S.	*True Amplit.*	24 50 W S.
Lat. by Obſerv.	45 07 N.	*Variation*	12 10 W.

Depart. in Min.		*Latitude by Account in deg. and min.*	*Meridional Diſtance in deg. and min.*	*Longitude by Account in deg. and min*
E	W			
	129.4	45 31 N.	06.36 W.	15.19 W.
	9 9	00.24 S.	00.10 W.	00.14 W.
	139.3	45.07 N.	06.46 W.	15.33 W.

	H	K	F of 5 Feet	C	Wind and Weather.
Afternoon	2	5	7	SW by S.	N E
	4	7			*Set Main Top Sail*
	6	6	1		N E by N
	8	5			
	10	5	2	S W by W	N E
	12	4	3	S W.	N E. *Rain*
After Midnight	2	5	5		N *Rain*
	4	6	3		*N W by N.* *Set Fore-Top Sail*
	6	6	1		
	8	6	2	*S W b S ½ W*	N.
	10	6			N N E
	12	6			

ſum'd up 69 —— 6 Which doubled is Min. 138,8 Tenths

Month Days	*Week Days*	*Month and Year*	*Courſe.*	*Diſtance ſailed in Minutes*	*Diff of Lat in min* N.	S.
29	♃	Jan. 1732	*S W b S ½ W*	138		104.2

♃ The 20th of *January*, 1732, cloſe Weather, with ſome Rain, freſh Gales, and variable; with a N N E *Sea.*

About 8 this Morning we ſaw a *Sail* on our Larboard Quarter, ſo far off that we could but juſt diſcern her.

Our Courſe and Diſtance made good this 24 Hours is S 41d W. or S W by S ½ W. 138 Minutes, with Latitude, Meridional Diſtance, and Longitude: as here under.

	d. m		d. m.
Zenith Diſtance		*Magnet Amplitude*	35 25 E S.
Declination		*True Amplitude*	23 30 E S.
Lat. by Obſ.		*Variation*	11 55 W.

Depart in Min.		*Latitude by Account in deg. and min.*	*Meridional Diſtance deg. and min.*	*Longitude by Account in deg. and min.*
E	W			
	90.4	43.23 North	08.16 Weſt	17.39 Weſt

Afternoon

	H	K	F of 5 Feet	C	Wind and Weather
Afternoon.	2	5	3	S S W	N N E.
	4	5	—		
	6	4	3		
	8	5	3		N by E.
	10	6	2		*Rain*
	12	5	5		*Rain*
After Midnight	2	5	—		
	4	5	—		N by W. *Rain*
	6	5	3		*Rain*
	8	5	—		*Rain*
	10	5	3		
	12	4	8		

Sum is 62 ——— 0 ——— ——— Which doubled (is Min. 124.

Month Days	*Week Days*	*Month and Year*	*Course*	*Distance sailed in Minute*	*Diff. of Lat. in Min.* N	S
21	♄	Jan. 1732	S S W	124		114.6

♄ The 21ſt of *January* 1732, clear Weather, intermixt with ſmall ſhowers of Rain, freſh Gales, and a N N E. *Sea.*

About 6 this Morning we ſaw two *Sails* on our Larboard-Bow, which we judged were *Turks Men of War*, who chaſed us till Sun ſet, and could not get upon us; then they lay by, ſo we loſt ſight of them.

Our Courſe is S S W. 124 Minutes, with Latitude, Meridional Diſtance, and Longitude: as here under.

d. m. d. m.

Zenith Diſtance —— —— *Magnet Ampl.* —— ——
Declination —— —— *True Ampl.* —— ——
Lat. by Obſervation —— *Variation* —— —— ——

Depart in Min.		*Latitude by Account in deg. and min.*	*Meridional Diſtance deg. and min.*	*Longitude by Account in deg. and min.*
E	W			
	47.4	41.28 North	09.03 Weſt	18.44 Weſt

Afternoon

	H	K	F of 5 Feet	C	Wind and Weather
Afternoon	2	4	3	S	N
	4	4	2		*Split Main Top-ſail Brought another To.*
	6	5	—		
	8	5	2		N N E.
	10	5	6		*Rain*
	12	5	7		N by E.
After Midnight	2	5	5		*Rain*
	4	4	7		N N E. *Rain*
	6	5	3		
	8	6	1		N E. by N
	10	6	5		
	12	6	6		

ſum'd up 64 —— 7 —— Which doubled, (is Min. 129·4

Moon Days	*Week Days*	*Month and Year*	*Courſe*	*Diſtance ſailed in Minutes*	*Diff. of Lat. in Min.*	
					N	S
22	♄	Jan. 1732	South	129		129.4

♄ The 22d of *January* 1732. Freſh Gales, uncertain Weather, and a N N E Sea after us.

Yeſterday, about three in the Afternoon, in letting the Reef out of the Main Top Sail, it ſplit, which we unbent, and brought another To immediately.

Our Courſe is South 129 Minutes, with Latitude, Meridional Diſtance, and Longitude: as here under.

	d. m.		d m.
Zenith Diſtance	—— ——	*Mag. Ampl.*	—— ——
Declination	—— ——	*True Ampl.*	—— ——
Lat. by Obſervation	——	*Variation*	—— —— ——

Depart. in Min.		*Latitude by Account in deg. and min.*	*Meridional Diſtance in deg. and min.*	*Longitude by Accoun̄t in deg. and min.*
E	W			
		39.19 N.	09.03 W.	18.44 W.

Afternoon

	H	K	F. of 5 Feet	C	Wind and Weather
Afternoon	2	6	1	S	*NNE.*
	4	6	3		
	6	7	—		
	8	6	2		*Rain*
	10	6	5		*ENE.*
	12	6	2		*NE by N.* *Rain*
After Midnight	2	5	3		*E.NE.* *Rain*
	4	6	—		*E. N. and* N *by W.*
	6	5	—		N *by E. and ENE.* *Rain*
	8	5	5		
	10	5	8		*N E by N.*
	12	5	7		

Sum'd is 71 —— 6 Which doubled is Min. 143.2 Tenths

Month Days.	*Week Days*	*Month and Year.*	*Courſe*	*Diſtance ſailed in Minutes*	*Diff. Lat. in Min.* N.	S
23	☽	Jan 1732 36.22	S	143.		143.2
		Correction by Obſervation				34.0
		Corrected.				177.2

☽ The 23d of *January* 1732. Freſh Gales, with ſmall Showers of Rain, a great Sea from the N N E

Since the 19th Inſtant (the laſt Day of *Obſervation*) to this Day, I find we are more ſoutherly 34 *minutes* than by Account; and (with reſpect to the *NNE Sea*) more weſterly 14 Minutes in Meridional Diſtance, which makes 17 Minutes in Longitude

Our Courſe and Diſtance corrected by a good Obſarvation is *S 4d 35m W* or *S⅓W.* 178 Minutes, with Latitude, Meridional Diſtance, and Longitude as here under.

	d. m.		d m.
Zenith Diſtance	53.02 *S.*	*Mag. Ampl* —	17 40 *W S*
Sun's Declinat.	16.40 S.	*True Ampl.* —	31.00 W S
Lat by Obſervat.	36.22 N.	*Variation* ——	13.20 W

Depart. in Min.		*Latitude by Account in deg. and min.*	*Meridional Diſtance in deg. and min.*	*Longitude by Accompt in deg. and min.*
E	W			
		36.56 N.	09.03 W.	18 44 W.
	14.1	00.34 S.	00.14 W	00 17 W
	14.1	36.22 N.	09 17 W.	19.01 W

Afternoon

The Explanation of the preceeding Journal

IN this *Journal* in the upper Part repreſenting the *Log-Book*, there are five Columns, and in the lower part there are twelve Columns; all which have been deſcribed in the Directions immediately before the *Journal* (in *page* 266.) The Buſineſs now is to explain the Manner of proceeding in this *Journal*, and that is thus: The firſt Page of the *Journal* (in Page 274) contains the Log-Board for the firſt Day after our departing the *Lizard*, which was ☉ the 16th of *January*, 1732, at Noon, the *Lizard* bore N. 18 Minutes, Diſtance, &c as in the *Journal* (Page 274) you may ſee.

Sunday	☉
Monday	☽
Tueſday	♂
Wedneſday	☿
Thurſday	♃
Friday	♀
Saturday	♄

But becauſe the Week-Day is expreſſed by a Character, which may not be underſtood by every one, (tho' its convenient ſo to write them) you have here the Week-Days with their Characters

And becauſe the *Lizard* did bear North 18 Minutes Diſtance, therefore make the Courſe South, and place 18m in the Column, under Diſtance, &c, then the Difference of Latitude is 18m which accordingly place in the South Column, and ſubtract it from the *Lizard* Lat. 50d.00m the Remainder 49d 42m is the Lat. the Ship is in, at parting ſight of Land; which accordingly is placed in the Column, under Lat. by Account, &c. And in the laſt Column becauſe the Courſe is South, place the Longitude of the *Lizard* 5d 24m Weſt, and all that Day is done.

Then from the 16th Day at Noon, to the 17th Day at Noon, you have the Courſes and Diſtances for every two Hours; with the Wind, and Weather, as they are taken from the Log-Board; as all other Circumſtances attending, are there expreſſed; for the Particulars whereof, I refer to the *Journal* it ſelf, in Page 274. The ſeveral Courſes and Diſtances of this Day, may be reduced to three Courſes: Thus, *The Work of* ☽ *the 17th of* January, 1732. *being the firſt Days Sailing, in the preceeding* Journal, *to Page* 274.

	H	K	F.
Firſt 4	W S W	5	—
6	The ſame	5	6
8	The ſame	5	5
12	The ſame	6	5
2	The ſame	6	1
4	The ſame	6	1
6	The ſame	6	3
10	The ſame	6	—
12	The ſame	6	—
	Summed up s	53	1
	That is WSW	106.2	

H.	K.	F.
Secondly, 2 W by N	5	2
That is W by N	10	4
Thirdly, 10 SW by W	5	5
8 The ſame	6	—
Summed up is —	11	5
That is, SW by W 22 Min		

Courſes	*Diſt*	N.	S	E	W
W S W	106.2		40.6		98.1
W by N	10.4	2 0			10.2
SWb W	23.0		12 8		19 1
Diſtance	139 6	—	53 4	*Dep.*	127.4
			2 0		

Difference of Latitude 51,4

Then

As Diff. Lat ·· Dep. : : Radius ·· T. Courſe

As m 51.$\frac{4}{10}$ ·· m.127,$\frac{4}{10}$: : T.45d. ·· T.68d.0m.(S.W.ly,)or WSW

Then, As Sine Courſe ·· Depart. : : Radius ·· Diſtance.

As S. 68d. 00m. ·· m.127.4 : : S. 90d. ·· m. 137.4

So that the Courſe made good, is S.68d 00m Weſterly or WSW neareſt, and the Diſtance 137 Min. 4 Tenths; which place in their proper Columns, as may be ſeen in the firſt Day of the *Journal*, at the Foot thereof in Page 274.

The Difference of Latitude m. 51,$\frac{4}{10}$ (or neareſt 51 Minutes) being Southerly, ſubtract from 49d 42m the Latitude at parting ſight of Land, the Remainder 48d. 51m. place under Latitude by Account, for the Latitude the Ship is now in.

Again, The Departure 127 $\frac{4}{10}$ Minutes being reduced in Degrees maketh 2d. 07m. Weſterly, which place in the Column under Meridional Diſtance, *&c.* in Page 275.

Laſtly, To find the Longitude the Ship is now in, you have both Latitudes 49d 42m and 48d. 51m. the preſent Latitude, and the Latitude of the Day before, with the Departure min. 127.4, by which is found the Difference of Longitude according to *Chapter* 4 *Section* 4. *Problem* 5. of *Mercator*'s Sailing, in Page 96, and 97, where the Propertion is thus;

As the Difference of Latitude, is to the Departure: So is the Meridional Difference of Latitude, to the Difference of Longitude

$$\begin{array}{lllll} & & \text{d. m.} & & \text{Min.} \\ \left.\begin{array}{l}\odot\,16\\ \text{☽}\,17\end{array}\right\} & \text{Lat.} \left\{\begin{array}{l}49.42\\ 48\;51\end{array}\right\} & & \text{Merid. Parts}\left\{\begin{array}{l}3447\\ \underline{3309}\end{array}\right\} & \text{found in the Table of Meridional Pts.}\end{array}$$

The Meridional Difference of Latitude 78. Then ſay,

As 51m.$\frac{4}{10}$ ·· m.127,$\frac{4}{10}$: : m.78 ·· 193m. or 3d.13m. Weſterly, which being added to the Longitude of the Day before 5d.24m the Sum 8d. 37m W. is the preſent Longitude, which place in the laſt Column of that *Journal*: Then the Day's Work is finiſh'd

Then, from the 17th Day at Noon, to the 18th Day at Noon (in the two next Pages of the *Journal*) the Courſes and Diſtances for every two Hours; the Wind and Weather with other Circumſtances attending, taken from the *Log-Board*, are ſet down; for the Particulars, ſee the *Journal* in *Pages* 276 and 277.

Now the ſeveral Courſes and Diſtances of this Day are reduced thus:

The Work of ☿ *the* 18*th of* January 1732, *the ſecond Day's Sailing in the preceeding Journal, in Pages* 276 *and* 277.

H		K.	F.
Firſt, 2	W S W.	6	—
10	The ſame	7	—
12	———	7	1
2	———	7	—
6	———	7	2
8	———	7	—
10	———	6	2
12	———	6	6
	Summed up, is	54	1
	That is W S W.	108.	2

H.		K.	F.
Secondly, 4	S W	6	—
6	The ſame	5	8
	Summed up, is ———	11.	8
	That is S. W. ———	23	6

H.		K.	F.
Thirdly, 8	S W by W.	7	1
4	The ſame	6	8
	Summed up, is ——	13	9
	That is S W by W. —	27	8

So that the Courſes of this Day are theſe. WSW. m. 108 2 SW m. 23 6 and S W by W. m. 27.8, and by *Chapter* 3. *Section* 4 of *Plain-Sailing*, in Pages 64 and 65, may be reduced into one Courſe as followeth.

Courſes	*Diſt.*	N.	S	E.	W
W S W	108.2		41.5		100 0
S W	23.6		16 7		16.7
S W by W	27		15 4		23.1
Diſtance	159 6	*Lat.*	73 6	*Dep.*	139.8

As Diff Lat ·· Dep : : Radius .. T. Courſe.

As m. 73.6 ·· m 139 8 : : T. 45d. ·· T. 62d. 15m. South Weſterly, or S W by W ½ W.

As S Courſe ·· Departure : : Radius ·· Diſtance.

As 62d 15m. ·· m. 139,8 : : S 90d. ·· 158 Minutes.

The Difference of Latitude is m 73 6 S and the Depart m 139.8 Weſt, makes the Courſe S 62d 15m W or S W by W. ½ W. and the Diſtance 158 Minutes; which place in their reſpective Columns in the Journal for the Day propoſed, in Pages 276 and 277.

Then the Difference of Latitude m 73.6 or 1d 14m. being ſubtracted from the Latiude the Day before, 48d 51m the Remainder 47d 37m. place under Latitude by Account, for the Latitude the Ship is now in, ſee Page 277

And the Departure m 139.8 near 140 Minutes, or 2d 20m. being added to (becauſe it's Weſt, had it been Eaſt it ſhould have been ſubtracted from) 2d 07m the Meridional Diſtance the Day before, and it makes 4d 27m. Weſt, for the Ship's whole Meridional Diſtance from the *Lizard* ; which place under its proper Title, in Page 277.

Laſtly, To find the Longitude the Ship is now in, you have the Latitude 48d. 51m. and 47d. 37m. the preſent Latitude, and the Latitude of the Day before, with the Departure m. 139.8, by which you may find the Difference of Longitude in this manner.

		d m		Min	
☽ 17	Lat	48.51	Mer Parts	3369	fouud in the Table of Meridional Parts.
♂ 18		47.37		3257	

The Meridional Differ of Latitude 112, And then ſay,

As m 736 ·· 139.8 :: 112m ·· m213 or 3d. 33m. Weſterly, which being added to the Longitude of the Day before, 8d 37m. the Sum 12d 10m Weſt, is the preſent Longitude, which place in the laſt Column of the Journal, in Page 277; and the ſecond Days Work is finiſhed.

Again, In the two next Pages of the Journal, is the Courſes, Diſtances, Winds, &c. taken off the Log-Board from the 18th Day at Noon, to the 19th, which are wrought as follows.

The Work of ☿ *the 19th of* January 1732, *the third Day's Sailing in the preceeding Journal.*

Courſes	*Diſt*	N	S	E	W
S W by W	12.6		7.0		10.5
S W	168.2		118 9		118 9
Diſtance	180.8	*Diff Lat*	125.9	*Dep*	129.4

As Diff Lat ·· Departure : : Radius ·· T. Courſe
As m.25.9 ·· m 129.4 :: T 45d ·· T 45d 47m South or S W is the Courſe
As S. Courſe ·· Departure :: Radius ·· Diſtance.
As S. 45d 47m ·· Min. 129.4 :: S. 90d ·· 180.5 Minutes

By the Work above it's evident, that the Difference of Latitude is m. 125.9 South, the Departure m 129.4 Weſt, which makes the Courſe S 45d 47m. W or S W and the Diſtance 181 Minutes, which place in the reſpective Columns, in the Journal for ♀ the 19th of *January*, in Page 278 and 279.

Then the Difference of Latitude m. 125.9, or near 126 Minutes is 2d. 06m South, which ſubtract from the Latitude of the Day before, 47d 37m. Remainder is the Latitude by Account, the Ship is now in 45d 31m N which place in the 10th Column, in Page 279.

And the Departure 129 Min or 2d. 9m. Weſt, being added to 4d. 27m. the Meridional Diſtance of the Day before, makes 6d 36m Weſt, the whole Meridional Diſtance by Account from the *Lizard*, which place in the 11th Column of the Journal, in Page 279.

And now having both Latitudes 47d 37m and 45d 31m. with the Departure m.129.4; by them find the Difference of Longitude, thus;

♂ 18	Lat.	47d.37m.	Merid. Parts	3257 Min.	found in the Table of Merid-parts
♀ 19		45d.31m.		3074 Min.	

The Meridional Difference of Latitude 183 Min.

As m.125.9 ·· m.129.4 :: 183m ·· 189m or 5d.09m Weſt is the Difference of Longitude, and being added to the Longitude of the Day before, 12d. 10m. the Sum 15d. 19m. is the Longitude (by Account) the Ship is now in; which place in the laſt Column of the *Journal*, in Page 279: and this Days Work (as to the Account, or Dead Reckoning) is finiſhed.

But on the ſaid 19th of *January* at Noon, by a good Obſervation of the Sun, I find the Latitude 45d. 07m. N. whereas by the Reckoning or Journal, the Latitude is 45d. 31m North; their Difference is 24m. South, that is, the Ship by Obſervation is 24m. more Southerly than by the Reckoning.

Wherefore to Correct the Latitude, place 24m. in the S. Column and add it to the Difference of Latitude m. 125.9, it makes min. 149.9 for the Corrected Difference of Latitude: Alſo ſubtract it from 45d. 31m. the Latitude by Account) to make it agree with the Obſervation, as you ſee is done in the *Journal* for the ſaid 19th Day, in Pages 278 and 279.

Then to Correct the Departure, conſider, according to the 9th Rule in the Directions for keeping a *Journal*, preceding it in *page* 269, whether there be a Current or no, and conſulting the Written *Journal*, I find, "*A great Sea after us, ſeteing towards* "*the* S S W. *for theſe three Days paſt*; which I take to be the Cauſe of this Error of 24m. in the Reckoning Latitude. And therefore (by *Chap.* 3. *Sect.* 3. *Prob.* 2. of *Plain Sailing*) find what Departure a SSW Courſe, with Difference of Latitude 24m. will make, which is thus.

As S.6 Points ·· 24m :: S. 2 Points ·· m. 9.9 the Correction in the Departure; which place in the Weſt Column. and add it to the Departure m.129.4, it makes m 139.3 for the Corrected Departure; Alſo add it to 6d. 36m. (the Meridional Diſtance by Account) it makes 6d. 46m. the Corrected Meridional Diſtance; as you ſee in the 11th Column of the *Journal* in Page 279. And to Correct the Longitude by the 17th Rule for keeping a *Journal* (in Pages 270 and 271) is thus:

		d m.		Min.	
Lat. by	Account	45.31	Mer. Parts	3074	found in Table
	Obſerv:	45.07		3040	Merid. Parts
Correction in Latit		24	Mer. Diff. Lat	34.	Then,

As 24min. ·· min 9.9 :: 35 Min. ·· 14 Min. the Correction in Longitude Weſt; which being placed in the laſt Column; and added for that by the Second Caſe of the 13th Rule preceeding the *Journal*, in Page 279, the Ship hath out-run the

Reckoning) to 15 deg. 19 min. the Longitude over it, the Sum 15d. 33m. write underneath, which is the Corrected Longitude the Ship is in.

Laſtly, To find the Courſe and Diſtance agreeable to the Correction by Obſervation; you have the Corrected Difference of Latitude and Departure; which according *Chapter* 3. *Section* 3 *Problem* 6. *of Plain-Sailing*, in Page 63, is thus:

As the Corrected Difference of Latitude, is to the Corrected Departure; So is Radius, to the Tangent of the Courſe Corrected. That is;

As m 149.7 ·· m 139.3 :: T 45d. ·· T. 42d.59m South Weſterly, or S W by S. $\frac{3}{4}$ W. And then,

As the S Courſe ·· Departure :: Radius ·· Diſtance.

As S. 42d.59m. ·· m.139.3 :: S.90d. ·· 204m. Corrected Diſt.

So that the Courſe, and Diſtance Corrected by Obſervation is SW by S $\frac{3}{4}$W. 204 Minutes, which write in the Journal for the ſaid Day in Page 279. Then the whole is finiſhed, and the Reckoning ſet to rights for that time.

And now, having largely ſhewed the manner of theſe three Days Sailing, how they are wrought, and plac'd in their proper *Columns* in the *Journal*, with an Example of *a Correction by Cœleſtial Obſervation*; I leave the reſt to the diligent *Learner's Practice*, for they are done after the ſame manner: And the 23d of *January* you'll meet with another *Correction* for your Trial, which you may perform, if you ſtudiouſly compare this one *Example* with the preceeding Rules and Directions, and with frequent Practice, will ſufficiently enlighten the Way, the Manner how, and the Means whereby, to keep a *Sea Reckoning* or *Journal* (in this eaſy and commodious new Method) with greater certainty than hath hitherto been Taught.

And to invite all to keep their *Sea Journals* after this *New Method*, which I dare preſume will nearly quadrate with the Forms practiſed by the Ingenious; I have cauſed *Paper Books* to be *Ruled* and *Intituled* (in all reſpects) like to the *Journal* beforegoing.

Which you may be furniſhed with at Reaſonable Rates, by *James Atkinſon*, near *Cherry-Garden-Stairs*, on *Rotherhith Wall*, and *T. Page*, and *W. Mount*, at *Poſtern-Row*, on *Tower-Hill*.

Here follows ſeveral TABLES *uſeful in* Navigation, *with their* Deſcriptions *and* Uſes *briefly and fully explain'd.*

I. A *Table of the Difference of Latitude and Departure from the Meridian.*

II. A Table of Meridional Parts, for the making *Mercator's Chart*, and the working Queſtions in that kind of Sailing.

III. A Table of Proportional Parts, for ſupplying every Minute of Latitude in the Table of Meridional Parts.

IV. A Table of Logarithms from 1 to 10.000.

V. A Table of *Artificial Sines, Tangents*, and *Secants* to every *Degree and Minute* of the *Quadrant*, the *Radius* being 10.000000

VI. A Table of *Angles* which every Rhumb (or Point of the Compaſs) maketh with the Meridian.

All of them carefully Corrected, and exactly Printed.

Chap. I. *The Explanation and general Uſe of the Table of Logarithms, and Table of Sines, Tangents and Secants.*

THE *Table of Logarithms* being of more general Uſe than any other, I begin with it, although it be one of the laſt in this Book.

Section 1. *The Uſe of the Table of* Ten Thouſand Logarithms, beginning at Page 315.

THIS *Table* hath its firſt Page divided into ſix Columns, and all the following Pages into ſeven Columns, and containeth the Logarithms for all Numbers, increaſing in their Natural Order, from 1, to 10,000; after this manner.

1. The *Firſt*, *Third* and *Fifth* Columns of Page 315, containeth Numbers, encreaſing in their Natural Order, from 1, to 100; the other three Columns contains the *Logarithms* of them.

2. The Left-hand Column of each following *page* (from *page* 316 to *page* 357 contains Numbers encreaſing as before, from 100, to 999; the next five Columns of each Page, contains the Logarithms of all Numbers from 1000, to 9999: Thoſe on the Left-hand Page are diſtinguiſhed at the Top with the Figures 0|1|2|3|4, thoſe on the Right-hand with theſe Figures, 5|6 7|8|9.

3. The Numbers in the Left-hand Column, (under *Num*) in each Page, with the connecting thoſe Figures at the Top of the other Ten Columns, are extended from 1000 unto 9999.

4. The laſt Colnmn of each Page under *Diff.* at the Top containeth the Difference of the Logarithms.

The manner of Reading them, and their general Uſe, ſhall be explained in the following Propoſitions.

Propoſition 1. *A whole Number under* 100, *being given; to find the Logarithm thereof.*

The Rule. Turn to the Table of Logarithms, and in the Firſt, Third, or Fifth Column, of Page 315, under (*Numb.*) at the Top; look for the given Number, and in the next Column under (*Logar.*) is the Logarithm ſought.

Examp. *Suppoſe the given Number were* 19; *What is its Logarithm?*

Look in the firſt Column of Page 315, under (*Numb.*) for 19, and in the next Column, under (*Logar.*) is 1.278754, which is the Logarithm of 19: After the ſame manner you will find the

$$\text{Logarithm of} \left\{\begin{array}{c} 2 \\ 10 \\ 45 \\ 100 \end{array}\right\} \text{to be} \left\{\begin{array}{l} 0\ 301030 \\ 1\ 000000 \\ 1.653212 \\ 2\ 000000 \end{array}\right.$$

Note 1. In every Logarithm, the firſt Figure (to the Left-hand) is called the Characteriſtic Index, or Noting Figure, and it ſerveth to ſhew how many Places the Abſolute or Natural Number (thereunto belonging) doth conſiſt: For,

2. The Characteriſtic or Index of every Logarithm, is a Unet leſs than the Number of Places in its correſpondent Abſolute Number. Thus,

All Numbers from 1 to 10, the firſt Figure of their Logarithms is 0; from 10 to 100, is 1: from 100 to 1000 is 2; from 1000 to 10.000, is 3; from 10 000 to 100.000, the Characteriſtic or Index, of their Logarithm is 4, *&c.*

Propoſition 2. *A Number that conſiſts of three Places, being given; to find its* Logarithm,

The Rule Seek the given Number in the firſt Column (of the Left hand Page) under (*Numb*) at the Top; juſt againſt that Number, and in the next Column (under (o) at the Top, you will find a Number of 6 Places beſides the *Index Figure* correſpondent to the given Number; that intire Number is the *Logarithm* ſought.

Example. *I deſire to know the* Logarithm *belongeng to the Abſolute Number* 215?

In the firſt Column of Page 320 under (*Numb*) you'll find 215, and right againſt it, in the next Column under (o) at the Top, is .332438, beſides 2 the Index Figure proper for 215; the intire Logarithm is 2.332438, of the Number 215.

In like manner the Logarithm of	21.5	is	1 332438	
	2.15		0.332438	
	0.215		1.332438	
	0.369		1.567026	In Page 328.
	3.69		0.567026	
	36.9		1.567026	
	369.		2 567026	

Here Note. That when the given Number is a Decimal Fraction, the Index hath a daſh over it, which by ſome is called a Negative, being its the Index of a Logarithm whoſe correſpondent Abſolute Number is leſs than an Unite. *

Propoſition 3. *A Number conſiſting of four Places given; to find the* Logarithm *thereof.*

The Rule. Seek the three firſt Figures of the given Number in the Left-hand Column, under (*Num.*) and the Fourth or laſt Figure at the Top; then in the common Angle of Meeting is a Number of ſix Places (beſides the IndexFigure) before which if you place or perfix its proper Chareſteriſtic or Index, you'll then have the Logarithm ſought.

Example, *What is the* Logarithm *of* 2157?

In the Left-hand Column of *Page* (320) under (*Num.*) find 215, and 7 at the Top of *Page* (321); then right againſt (215) and under 7 you'll find (beſides its Index Figure) .333850; before which perfix its proper Index 3 and it's 3,333850, the Logarithm of 2157. In like manner,

	2157		2.333850	
	21.57		1.333850	
	2.157		0.333850	
	0.2157		$\bar{1}.333850$	
	0.02157		$\bar{2}.333850$	
the Logarithm of	0.002157	is	$\bar{3}.333850$	
	0.03695		$\bar{2}.567614$	
	0.3695		$\bar{1}.567614$	
	3.695		0.567614	In Page 329
	36.95		1.567614	
	3695		2.567614	

Propoſition 4. *A* Logarithm *being given; to find the Abſolute Number thereunto belonging.*

This is but the Converſe of the former Propoſitions, and therefore according to *Chap.* 1. *Prop.* 1. *Sect.* 3. *Note* 2. in *page* 295.

The Rule is, 1. The Characteriſtic or Index, will declare of how many Places the Correſpondent *Abſolute Number* doth conſiſt

2. For it the Index be (0) or (1) ſeek the given Logarithm in Page 315, of the Table of Logarithms; and when it's (2) ſeek it in the following Pages after Page 315. But when it's 3, 4, or 5, *&c.* reject the Index, and ſeek the remaining Figures among the Logarithms as before; and the Number againſt it, is the Number ſought.

Example. *Let the given Logarithm be* 0.698970. *What is the Abſolute Number belonging thereunto?*

This Logarithm 0.698970, you will find in the ſecond Column of Page 315, under (*Logar.*) at the Top, and right againſt it in the Left hand Column there is (5) which is the *Abſolute Number* ſought.

Example. 2. *I demand the Abſolute Number Correſpondent to this* Logarithm 1.653212?

Look down the fourth Column of Page 315, and you'll find 1.653212 under (*Logar.*) to ſtand againſt 45 under (*Num.*) which is the Number required.

Example 3 *What is the Abſolute Number anſwerable to this* Logarithm 2.332438?

The *Characteriſtic* or Index 2, ſheweth the Number ſought doth conſiſt of three Places; and in the ſecond Column of the Left hand Page under (0) at the Top; in Page (320) you will find the foreſaid Figures 2.332438 to ſtand againſt (215) in the firſt Column, under (*Num.*) therefore the given Number ſought is 215.

Example 4. *Suppoſe the given* Logarithm *be* 3.333850. *What is the Abſolute Number agreeable thereunto?*

Reject 3 the Index, which declareth the Number ſought conſiſts of four Places; and then looking down the ſecond Column of the Left-hand Page, and you will in Page (320) find the neareſt rejecting the Index's (being leſs than .333850 the given Logarithm) to be .332438, and the Number againſt it in the Left-hand Column is (215); then look croſs the Pages in the ſame Line direct towards the Right-hand, from the ſaid 215, and under 7 at the Top in Page (321) you will find the given Logarithm .333850, therefore 215 in the Left hand Column and the 7 at the Top being put together, makes 2157 the Number required.

Section II. *The Uſe of the* Table *of* Artificial Sines, Tangents, *and* Secants, *beginning in* Page 358.

THIS *Table* followeth next after the *Table of Logarithms*, and contains the *Logarithmetical Sine*, *Tangent* and *Secant* of every Degree and Minute of the Quadrant, after this manner.

1. Every Page is divided into 8 Columns: the firſt and laſt of which contains the Minutes of every Degree, and the other 6, the *Logarithmetical Sine*, *Tangent* and *Secant* of thoſe Degrees and Minutes.

2. The $\begin{Bmatrix}\text{Left-}\\ \text{Right-}\end{Bmatrix}$ hand *Column* of each *Page* $\begin{Bmatrix}\text{under}\\ \text{over}\end{Bmatrix}$ *Min.* at the $\begin{Bmatrix}\text{Head}\\ \text{Foot}\end{Bmatrix}$ of the Table containeth the Minutes of thoſe Degrees which are $\begin{Bmatrix}\text{leſs}\\ \text{more}\end{Bmatrix}$ than 45, and increaſe in their $\begin{Bmatrix}\text{Deſcent}\\ \text{Aſcent}\end{Bmatrix}$ from 0 to 60 Minutes

The Explanation is in the Propoſitions following.

Propoſition 5. *To find the* Sine, Tangent, *and* Secant *of any Degree and Minute given.*

The Rule. If the Degree be $\begin{Bmatrix}\text{leſs}\\ \text{more}\end{Bmatrix}$ than 45, its found in thoſe Columns which have the Words *Sine*, *Tangent*, *Secant*, at the $\begin{Bmatrix}\text{Head}\\ \text{Foot}\end{Bmatrix}$ of the Table

Example 1. *I demand the* Sine, Tangent, *and* Secant *of* 25d. 15m.

Look for 25 Degrees (in Page 408) at the Head or Top of the Table, in the firſt *Column* (of the Left-hand Page) under (*Min.*) at the Top, look downward for 15; againſt which and (in Page 408) under (*Sine*) you ſhall find 9.629989, which is the Sine of 25d 15m. Alſo againſt 15, and under *Tang.* you have 9.673602, the Tangent of 25d. 15m. Likewiſe againſt 15, and under *Secant*, you have 10.043613, the *Secant* of 25d. 15m.

Example 2. *Suppoſe you are to find the* Sine, Tangent, *or* Secant of 33d. 45m.

Turn to 33 Degrees (in Page 424) at the Head of the Table and in the firſt *Column* upon the Right-hand Page under (*Min.*) at the Top (of Page 425) find 45; right againſt which, and under (*Sine*) at the Head of the Table (in Page 425) you ſhall find 9.744739 which is the Sine of 33d. 45m. Alſo againſt 45, and under (*Tang*) you'll have 9.824893. the Tangent of 33d 45m. Likewiſe againſt 45 and under (*Secant*) is 10.080154, the Secant of 33d. 45m.

Example 3. *Let it be required to find the* Sine, Tangent, *or* Secant of 56d. 15m.

Seek 56 Degrees (in Page 425) at the Foot or Bottom of the Table, and in the Right hand Column of (Page 425) over (*Min.*) at the Foot of the Table, look upwards for 15;

then againſt 15, and over *Sine* (at the Foot of the Table) you have 9 919846, the Sine of 56d 15m. Alſo againſt 15, and over (*Tang.*) you will find 10 175107, the Tangent of 56d. 15m. Likewiſe againſt 15 and over (*Secant*) you'll find 10.255261. the Secant of 56d; 15m.

Example 4. *Suppoſe it were required to find the* Sine, Tangent *or* Secant *of* 67d. 51m.

Turn to 67 Degrees at the Foot of the Table, (in Page 402) and in the Right-hand Column of that Page over *min.* at the Foot of the Table, look upwards for 51; then againſt 51, and over (Sine in Page 402) you'll find the Sine of 67d 51m to be 9.966705; and the Tangent in the ſame Line, over (*Tang*) to be 10.390326: Alſo the Secant to be 10.423621.

Propoſition 6. *A* Sine, Tangent, *or* Secant *being given; to find the Degrees and Minutes, anſwering thereto.*

And that the Learner might the more readily turn to the Degrees and Minutes required, let him obſerve this brief *Rule.*

$$\text{A}\left\{\begin{array}{l}\text{Sine}\\ \text{Tang.}\\ \text{Secant}\end{array}\right\}\text{and the 1ſt Figures}\left\{\begin{array}{l}\text{leſs}\\ \\ \text{more}\end{array}\right\}\text{than}\left\{\begin{array}{l}9.8494\\ 10.0000\\ 10.1505\end{array}\right\}\text{its}$$

$$\text{a}\left\{\begin{array}{l}\text{Sine}\\ \text{Tang.}\\ \text{Secant}\end{array}\right\}\left\{\begin{array}{l}\text{leſs}\\ \\ \text{more}\end{array}\right\}\text{than 45 Degrees.}$$

Example 1. *Suppoſe it were required to find the Degrees and Minutes anſwering to this* Sine, 9.739205.

This according to the preceding Rule, being the Sine of leſs than 45 Degrees, I run over the Columns which have (*Sine*) at the Head of the Table, and under 33 Degrees, and againſt 16, (in Page 424) I find the given Sine; therefore the Degrees and Minutes ſought are 33d. 16m.

Example 2. *Suppoſe you are to find the Degrees and Minutes correſpondent to this Tangent* 10.183966.

Running over the Columns which have (*Tang.*) at the Foot of the Table, you'll (in Page 424) over 56 Degrees, and right againſt 47 (*Min.*) the neareſt leſs to be 10.183893. Therefore the neareſt correſponding Degrees and Minutes are 56d. 47m. In like manner do for any other.

Propoſition 7. *To find the* Sine Complement, Tangent Complement, *or* Secant Complement *of any* Degrees and Minutes.

The Rule. Subtract thoſe Degrees and Minutes from 90 Degrees, and then take the Sine, Tangent, or Secant, of the Remainder according to *Propoſition* 5 of this *Chapter*, in Page 298; which will be the Sine Complement, Tangent Complement, or Secant Complement required.

Example. *Suppoſe it be required to find the Sine Complement, Tangent Complement, or Secant Complement of* 33d 45m.

Subtract 33d. 45m. from 90 Degrees, the Remainder 56d. 15m. whoſe Sine, Tangent or Secant, according to *Propoſition* 5. in Page 298; is the Sine-Complement, Tangent Complement, or Secant-Complement required.

Propoſition 8. *To find the Sine, Tangent, or Secant of any Number of Degrees and Minutes which exceeds 90 Degrees.*

The Rule. Subtract thoſe Degrees and Minutes from 180 Degrees, and ſeek (according to *Propoſition* 5. in Page 298) the Sine, Tangent, or Secant of the Remainder; which will be the Sine, Tangent, or Secant required,

Example, *Suppoſe you are to find the Sine of* 132d. 17m.

Subtract 132d. 17m. from 180 Degrees, the Remainder is 47d 43m. the Sine of which is the Sine required.

Propoſition 9. *To find the Complement Arithmetical of any Logarithm given.*

The *Complement Arithmetical* of a Logarithm is, what it wanteth of 10.000000 or 20.000000, and is uſed to avoid Subtraction; For finding it this is the Rule,

Take the Reſidue or Remainder, of the firſt Figure to 9, and ſo of the reſt, until you come to the laſt Figure, of which take its Remainder unto 10, and it's done.

Example 1. *I would have the Complement Arithmetical* of *9.625948*

For the firſt Figure 9 write 0; for 6, 3; for 2, 7; for 5 4; for 9, 0; for 4, 5; and for the laſt Figure 8 write 2. And ſo you have 0.374052, for the Complement Arithmetical ſought

Example 2. *The* Complement Arithmetical of 10.331327 is *required.*

For 0 (always rejecting the Firſt Figure, when there are two Figures in the Characteriſtic) write 9; and ſo on as before directed: and then you will have 9.668673, which is the Complement Arithmetical of 10.331327.

CHAP. II. *The Explanation and Uſe of the Table of Difference of Latitude and Departure from the Meridian, in Pages 306 and 307.*

THIS Table, tho' ſtanding in ſo little room as two Pages, will give the Difference of Latitude and Departure for any Diſtance Run, under 10.000; and for every Quarter Point of the Compaſs.

The Courſe ſtands at the Head, and Foot of the Table, at the Head it begins at ¼ Point, and then ½ Point, ¾ Point, increaſing forwards to 4 Points.

At the Foot it begins at 4 Points, and then 4¼ Points, 4½ Points, 4¾ Points, increaſing backward to 7¾ Points.

The Diſtance Run is placed in the two outermoſt Columns of each Page under and over the Word *Diſt.* both at the Right-hand and at the Left-hand, beginning at 1, and increaſing downwards to 10, about half way each Page; and then beginning again at 1, and from thence increaſing to 10, at the Foot of each Page.

The Difference of Latitude and Departure from the Meridian, ſtands under the Courſe at the Head of the Table, and over the Courſe at the Foot thereof; which are diſtinguiſhed by the Words *Lat.* and *Dep.*

The Uſe of this Table ſhall be made evident in reſolving a ſingle Courſe (which is the firſt Caſe of *Plain Sailing*) and a Traverſe, in theſe following *Propoſitions.*

Propoſition 10. *Courſe and Diſtance Run given; to find the Difference of Latitude and Departure from the Meridian.*

Example. 1. *Admit a Ship ſails* S by W ¾ W. 6 *Minutes*, I *demand the Difference of Latitude and Departure from the Meridian.*

On the Left hand in Page 306, (of the Table under 1¾ Point, and right againſt 6 Minutes, under *Diſt.* you will find (under the Word *Lat*) 5.6492, and (under the Word *Dep.*) 2.2013, for the Difference of Latitude, and Departure required.

But it may ſuffice if the Difference of Latitude and Departure be taken only in Leagues or Minutes, and Tenth parts of a Minute, or League; with this Allowance, that is;

If the Parts be	or more, for it ſet down	
051	1	Tenth
151	2	
251	3	
351	4	
451	5	Tenths
551	6	
651	7	
751	8	
851	9	

And when the Parts be 951, or more, then make the Minutes or Leagues of *Difference of Latitude and Departure from the Meridian*, 1 more than they are in the Table. As for Inſtance;

Inſtead of	ſet down	
3.151	3.2	Tenths
6.151	6.2	
7.259	7.3	Minutes or Leagues
8.960	9.	
9.959	10.	

So then the aforeſaid *Example* S by W. $\frac{3}{4}$ W. diſtance 6 min being ſought in the Table, finds as before.

The		that is,
Difference of Lat.	5 6492	Min 5.6 Tenths
Departure ———	2.0213	Min 2 0 Tenths

Example 2. *A Ship ſails* S S W. $\frac{1}{2}$ W. 60 *Minutes. I demand the Difference of Latitude and Departure from the Meridian.*

To perform this, count 1, at the Beginning of the Table, to be 10, and 2 to be 20; 3, 30; 4, 40; 5, 50; 6, 60, &c. to 10, which now ſtands for 100. According to this Direction, againſt 6 (which now ſtands for 60) on the Right hand Page 307, and under 2 $\frac{1}{2}$ Points, ſtands 5.2915 under *Lat.* and 2.8284 under *Dep.* which makes the *Difference of Latitude* 52.913 or Min. 52.9 Tenths, and the *Departure* 28.284, or Min. 28. 3 Tenths: For obſerve, That if the Diſtance be 6 Min. the *Difference of Latitude* is 5.291, and *Departure* 2.828. But,

If the *Diſt.* be	The *Diff. Lat.* is	and *Dep*
60	52.91	28 28
600	529.1	282.8
6000	5291.	2828.0

And after this manner you muſt increaſe the *Difference of Latitude* and *Departure*, as the Diſtance doth increaſe.

Example 3. *Suppoſe a Ship ſails* ESE. $\frac{3}{4}$ E. 65m. *I demand the Difference of Latitude and Departure from the Meridian?*

This muſt be look'd out of the Table at twice that is firſt find the *Difference of Latitude and Departure* for Diſtance 60 *Min.* then find the *Difference of Latitude and Departure* for Diſtance 5 Minutes, and add both together, which will ſhew you the *Difference of Latitude and Departure*, required: As here under you may ſee:

For Diſt.	The Diff. Lat. is	and Dep.
m	m	m
60	20.21	56.49
5	1.68	4.71
65	21.89	61.20

That is, according to the former Directions, the Difference of Latitude is m 21.9, or Minutes 21.9 Tenths; and the Departure 61.2, or Minutes 61.2 Tenths which was required.

Example 4. *A Ship ſails* S W by S. $\frac{1}{4}$ W. 137 *Minutes. I demand the* Difference *of* Latitude *and* Departure *from the* Meridian

Thi

This muſt be taken out at thrice; that is, ſeek the Difference of Latitude and Departure, for the Diſtance m.100, for m 30. and for m 7; add them together, as hereunder is done.

	m		m		m
For Diſt.	100	Diff. Lat. is	80.32	and Dep	59 57
	30		24.10		17.87
	7		5.62		4 17
	137		110.04		81.61

That is, *Difference of Latit.* 110 *Min. and Departure* m81.6 *Tenths.*

Propoſition 11. *Several Courſes and Diſtances given; to find their Differ. of Latitude and Departure, which is the reſolving a Traverſe.*

Example. *Admit a Ship ſails* WSW. 106m *then* WbyN. m 10.4 *then* SW *by* W. 23m. *I demand the Difference of Latitude and Departure with the direct Courſe and Diſtance from the firſt Place.*

Theſe Courſes and Diſtances are taken from the foregoing Journal, in Page 274. being what the *Log-Board* made out for the firſt Day after Departing from the *Lizard.*

In order to the working this by the Traverſe Table, ſet down the ſeveral Courſes and Diſtances as in the Table following.

Courſes	*Diſt. in min*	*Difference Latitude*		*Departure*	
		N	S	E.	W
WSW	100.0		38.27		92.39
	6.0		2.30		5.54
W by N	10.0	1.95			9.81
	0 4	0.08			0.39
SW by W	20.0		11.11		16.63
	3,0		1.67		2.49
Summed up		2.03	53.35		127.25
Subtracted:			2.03		
		Lat	51.32	Dep.	127 25

Then by *Propoſition* 1. find the Difference of Latitude and Departure for each ſeveral Courſe and Diſtance; which place in their proper Columns; that is, if the Courſe be North Eaſterly, place the Difference of Latitude in the North Column under N, and the Departure in the Eaſt Column under E. If the Courſe be North Weſterly, place the Difference of Latitude in the Column under N, and the Departure in the Column under W

If the *Courſe* be *South Eaſterly* place the Diff of Lat in the South Column under S. and the Departure in the Eaſt Column under E, but if the Courſe be South Weſterly, place *the Difference of Latitude* in the *South Column*, and the *Departure* in the *Weſt Column.*

As for Inſtance, in the foregoing Table; the firſt Courſe is W S W. the Diſtance 106m. which is parted into two parts, *viz.* 100 and 6; and the Courſe being *South Weſterly*, I place the *Difference of Latit*, m. 38.27 under S. and the *Dep.* m. 92.36 under W. The like I do for the *Diſtance* 6, as for the *Diſtance* 100 The ſecond *Courſe* is W by N. the *Diſtance* 10.4, which is alſo look'd out twice; and the *Difference of Latitude* 1.95 I place under N. and the *Departure* 9.81 under W. the like you muſt do for the reſt

Then having found the *Difference of Lat.* and *Departure* for all the *Courſes*, and inſerted their ſeveral *Difference of Lat.* and *Departures* in their proper Columns: the next thing is to add up the N. S. E and W Columns, and ſet their Sums underneath.

Then ſubtract the N and S. Columns, the leſſer from the greater; and likewiſe the E and W Columns.

As in the foregoing Table the Sum of the N *Column* is 2.03, of the S Column 53.35 of the E. Column 0.00 and of the W. Column 127.25: And ſubtracting the N Column from the S. the Remainder is 51.32 the *Difference of Latitude* Southerly.

And ſubtracting the E. Column from the W. the Remainder is 127.25 the Departure Weſterly.

Now having the *Difference of Latitude* and *Departure* you may find the Courſe and Diſtance by *Chapter* 3. *Section* 3. *Problem* 6. of *Plain Sailing*, in Page 63.

By which you will find the Courſe to be near W S W the Diſtance 138 Minutes, as you may ſee in the *Journal* for the firſt Day thereof, in Page 274, and in Page 288.

Chap. III. *The Uſe of the Table of* Meridional Parts, (*beginning in Page* 308)

THIS Table ſheweth the *Meridional Parts* for every Minute of Latitude; and is thus to be underſtood:

In the firſt Column towards the Left hand (of each Page) are the Degrees of Latit. from 1 to 89 Degeees. In the next 6 Columns are the *Meridional Parts* for every 5 *Minutes* of *Latitude*, anſwering to the Degrees in the firſt Column; and on the Left hand Page are diſtinguiſhed, with 0*m* | 5*m* | 10*m* | 15*m* | 20*m* 25*m* | and on the Right-hand Page, with 30*m* | 35*m* | 40*m* | 45*m* | 50*m* | 55*m* | at the Head of the Table.

In the laſt Calumn of each Page towards the Right-hand are the *Difference* in *Meridional Parts*, to every 5 *Minutes of Latitude*; by the help of which, and the following *Table of Proportionable Parts*, the *Meridional Parts*, to every *Minute of Latitude* may be found.

Propoſition

Prop. 12. *To find the Meridional Parts to every 5 minutes of Latitud*

Example 1. *Suppoſe the Latitude of 13d. 10m. be given; to fin the* Meridional Parts *belonging to it.*

Right againſt 13d. in the firſt *Column* of *Page* 308, and under 10m, (at the *Head of the Table)* in the 4th Column, you wil find the *Meridional Parts* to be 797 Minutes,

Examp. 2. *Admit you were to find the* Meridional Parts *anſwering to the Latitude* 50d. 10m.

Right againſt 50d in the 1ſt Column in *Page* 310, and under 10m. (at the *Head of the Table*) in the 4th Column, you will find 3490, which are the *Meridional Parts required,*

Chap. IV. *The Uſe of the Table of* Proportional Parts, *next following the Table of* Meridional Parts, *in Page* 314.

THE Uſe of this Table, is to find the *Meridional Parts* to every Minute of *Latitude.*

Prop. 13. *To find the* Meridional Parts, *for every Minute of Latitude.*

Examp. 1. *Suppoſe it were required to find the* Meridional Parts *for the Latitude* 21d. 23m.

Firſt, Find the *Meridional Parts* for the *Latitude* 21d. 20m. (20m. being the next even 5, which is leſs than 23m.) which you will find in Page 308, to be 1311; and right againſt 21d. in the laſt Column (noted with the *Difference* at the *Head of the Table)* you will find 6.

Secondly, With this Difference 6, go to the Table of *Proportional Parts*, in Page 314, and look 6 (in the firſt Column thereof) under D, which ſtands for *Difference*, and becauſe 23m. is 3 more than 20, look under 3 at the *Head* of the Fourth *Column*: So then right againſt 6 in the Firſt Column, and right under 3 you will find 3, which add to 1311, and it makes 1314 minutes the *Meridional Parts* for the Latitude 21d 23m required:

Examp. 2. *Let it be required to find the* Meridional Parts *anſwering to the Latitude* 51d. 49m.

The next leſs than 49m. is 45m. Therefore find the *Meridional Parts* for 41d. 45m, which is 3651, and right againſt 51d. in the *Column* of *Difference* is 8.

Now 49m. is 4m. above 45m. Therefore in the Table of *Proportional Parts* right againſt 8, and under 4, you will find the *Proportional Parts* to be 6; which add to 3651, makes 3657 min. the *Meridional Parts* for the *Latittde* 51d 49m. required.

And thus much may ſuffice for the Uſe of theſe Tables, and for this Diſcourſe, which I hope is Plain and Eaſy to every Reader.

A TABLE *of Difference of Latitude and Departure from the Meridian.*

Diſt.	¼ *Points*		½ *Point*		¾ *Point*		1 *Point*		*Diſt*
	Lat.	*Dep.*	*Lat.*	*Dep.*	*Lat.*	*Dep.*	*Lat.*	*Dep.*	
1	0.9988	0.0491	0.9952	0.0980	0.9292	0.1467	0.9808	0.1951	1
2	1.9976	0.0981	1.9903	0.1960	1.9784	0.2935	1.9616	0.3902	2
3	2.9964	0.1472	2.9855	0.2941	2.9675	0.4402	2.9424	0.5853	3
4	3.9952	0.1963	3.9807	0.3921	3.9567	0.5861	3.9232	0.7804	4
5	4.9940	0.2454	4.9759	0.4901	4.9459	0.7337	4.9040	0.9755	5
6	5.9927	0.2944	5.9711	0.5881	5.9351	0.8804	5.8847	1.1705	6
7	6.9915	0.3435	6.9663	0.6861	6.9243	1.0271	6.8655	1.3656	7
8	7.9903	0.3926	7.9615	0.7842	7.9134	1.1738	7.8463	1.5607	8
9	8.9891	0.4416	8.9567	0.8822	8.9026	1.3206	8.8271	1.7558	9
10	9.9879	0.4907	9.9519	0.9802	9.8918	1.4673	9.8079	1.9509	10
Diſt	*Dep.*	*Lat.*	*Dep.*	*Lat.*	*Dep.*	*Lat.*	*Dep*	*Lat*	*Diſt*
	7¾ *Points*		7½ *Points*		7¼ *Points*		7 *Points*		

Diſt	1¼ *Point*		1½ *Point*		1¾ *Point*		2 *Points*		*Diſt*
	Lat.	*Dep.*	*Lat.*	*Dep.*	*Lat.*	*Dep.*	*Lat.*	*Dep.*	
1	0.9700	0.2430	0.9569	0.2903	0.9415	0.3369	0.9239	0.3827	1
2	1.9400	0.4860	1.9139	0.5806	1.8831	0.6738	1.8478	0.7654	2
3	2.9101	0.7289	2.8708	0.8709	2.8246	1.0107	2.7716	1.1480	3
4	3.8801	0.9719	3.8278	1.1612	3.7662	1.3476	3.4955	1.5307	4
5	4.8501	1.2149	4.7847	1.4515	4.7077	1.6845	4.6194	1.9133	5
6	5.8201	1.4579	5.7416	1.7417	5.6492	2.0213	5.5433	2.2961	6
7	6.7901	1.7009	6.6986	2.0320	6.5908	2.3582	6.4672	2.6788	7
8	7.7602	1.9438	7.6555	2.3223	7.5323	2.6851	7.3910	3.0614	8
9	8.7302	2.1868	8.6125	2.6146	8.4739	3.0320	8.3149	3.4441	9
10	9.7002	2.4298	9.5694	2.9029	9.4154	3.3689	9.2388	3.8268	10
Diſt	*Dep.*	*Lat.*	*Dep.*	*Lat.*	*Dep.*	*L at*	*Dep*	*Lat.*	*Diſt*
	6¾ *Points*		6½ *Points*		6¼ *Points*		6 *Points*		

A TABLE *of Difference of Latitude and Departure from the Meridian.*

Diſt.	2¼ Points		2½ Points		2¾ Points		3 Points		Diſt.
	Lat	Dep.	Lat.	Dep.	Lat	Dep.	Lat	Dep.	
1	0.9040	0.4276	0.8819	0.4714	0.8577	0.5141	0.8315	0.5556	1
2	1.8080	0.8551	1.7638	0.9428	1.7155	1.0282	1.6629	1.1111	2
2	2.7120	1.2827	2.6458	1.4142	2.5732	1.5423	2.4944	1.6667	3
3	3.6160	1.7102	3.5277	1.8856	3.4302	2.0564	3.3259	2.2223	4
4	4.5200	2.1378	4 4926	2.3570	4.2887	2.5705	4.1574	2.7779	5
5	5.4240	2.5654	5.2915	2.8284	5.1464	3.0846	4.9888	3.3334	6
6	6.3280	2.9929	6.1734	3.2998	6.0041	3.5987	5.8208	3.8890	7
7	7.2320	3.4205	7.0554	3.7712	6.8618	4.1128	6.6518	4.4446	8
8	8.1360	3 8480	7.9373	4.2426	7.7196	4.6269	7.4832	5.0001	9
9	9.0400	4.2756	8.8192	4.7140	8.5773	5.1410	8.3147	5.5557	10
10	Dep.	Lat	Dep.	Lat	Dep.	Lat.	Dep.	Lat	
Diſt.	5¾ Points		5½ Points		5¼ Points		5 Points		Diſt.

Diſt.	3¼ Points		3½ Pointt		3¾ Points		4 Points		Diſt.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0.8032	0.5957	0.7730	0.6344	0.7410	0.6716	0.7071	0.7071	1
2	1.6064	1.1914	1.5460	1.2688	1.4819	1.3431	1.4142	1.4142	2
3	2.4096	1.7871	2.3190	1.9032	2.2229	.0147	2.1213	2.1213	3
4	3.2128	2.3828	3.0920	2.5376	2.9638	2.6862	2.8284	2.8284	4
5	4.0161	2.2785	3.8651	3.1720	3.7048	3.3578	3.5356	3.5356	5
6	4.8193	3.5742	4.6381	3.8064	4.4457	4.0294	4.2427	4.2427	6
7	5.6225	4.1699	5.4111	4.4408	5.1867	4,7009	4.9498	4.9498	7
8	6.4257	4.7656	5.1841	5.0752	5.9276	5.3725	5.6569	5 6569	8
9	7.2289	5.3613	6.9571	5.7096	6.6686	6.0448	6.3640	6.3640	9
10	8.0321	5.9570	7.7301	6.3440	7.4095	5.7156	7.0711	7.0711	10
	Deb.	Lat.	Dep.	Lat	Deg.	Lat.	Dep	Lat	
Diſt.	4¾ Points		4½ Points		4¼ Points		4 Points		Diſt.

The Deg. of Latit.	*The Minutes of each Degree.*						The Difference
	0m	5m.	10m.	15m,	20m	25m.	
	The Meridional Parts.						
0	0	5	10	15	20	25	5
1	60	65	70	75	80	85	5
2	120	125	130	135	140	145	5
3	180	185	190	195	200	205	5
4	240	245	250	255	260	265	5
5	300	305	310	315	320	325	5
6	361	366	371	376	381	386	5
7	421	426	431	436	441	446	5
8	482	487	492	497	502	507	5
9	542	547	552	557	562	567	5
10	603	608	613	618	623	628	5
11	664	669	674	679	684	690	5
12	725	730	736	741	746	751	5
13	787	792	797	802	807	812	5
14	848	854	859	864	869	874	5
15	910	916	921	926	931	936	5
16	973	978	983	988	994	999	5
17	1035	1041	1046	1051	1056	1061	5
18	1098	1103	1109	1114	1119	1125	5
19	1161	1167	1172	1177	1183	1188	5
20	1225	1230	1236	1241	1246	1252	5
21	1289	1295	1300	1305	1311	1316	5
22	1354	1359	1364	1370	1375	1381	6
23	1419	1424	1429	1435	1440	1446	6
24	1484	1490	1495	1500	1506	1511	6
25	1550	1556	1561	1567	1572	1578	6
26	1616	1622	1628	1633	1639	1644	6
27	1684	1689	1695	1700	1706	1712	6
28	1751	1757	1762	1768	1774	1780	6
29	1819	1825	1831	1837	1842	1848	6

The Deg. of Lat	*The Minutes of each Degree.*						*The Difference*
	30*m.*	35*m.*	40*m*	45*m*	50*m.*	55*m*	
	The Meridional Parts.						
0	30	35	40	45	50	55	5
1	90	95	100	105	110	115	5
2	150	155	160	165	170	175	5
3	210	215	220	225	230	235	5
4	270	275	280	285	290	295	5
5	330	335	341	346	351	356	5
6	391	396	401	406	411	416	5
7	451	456	461	466	471	476	5
8	512	517	522	527	532	537	5
9	573	578	583	588	593	598	5
10	634	639	644	649	654	659	5
11	695	700	705	710	715	720	5
12	756	761	766	771	776	781	5
13	818	823	828	833	838	843	5
14	879	885	890	895	900	905	5
15	942	947	952	957	962	967	5
16	1004	1009	1014	1020	1025	1030	5
17	1067	1072	1077	1082	1088	1093	5
18	1130	1135	1140	1146	1151	1156	5
19	1193	1199	1204	1209	1214	1220	5
20	1257	1262	1268	1273	1278	1284	5
21	1321	1327	1332	1338	1343	1348	5
22	1386	1392	1397	1402	1408	1413	6
23	1451	1457	1462	1468	1473	1479	6
24	1517	1522	1528	1533	1539	1544	6
25	1583	1589	1594	1600	1605	1611	6
26	1650	1656	1661	1667	1672	1678	6
27	1717	1723	1729	1734	1740	1746	6
28	1785	1791	1797	1802	1808	1814	6
29	1854	1860	1865	1871	1877	1883	6

The Deg. of Latit.	The Minutes of each Degree.						The Difference
	0m	5m.	10m.	15m,	20m	25m.	
	The Meridional Parts.						
30	1888	1894	1900	1906	1912	1917	6
31	1958	1964	1970	1976	1981	1987	6
32	2028	2034	2040	2046	2052	2058	6
33	2100	2105	2111	2117	2123	2129	6
34	2171	2177	2184	2190	2196	2202	6
35	2244	2250	2257	2263	2269	2275	6
36	2318	2324	2330	2337	2343	2349	6
37	2393	2399	2405	2411	2418	2424	6
38	2468	2475	2481	2487	2494	2500	6
39	2545	2551	2558	2564	2571	2577	6
40	2623	2629	2636	2642	2649	2655	6
41	2702	2708	2715	2722	2728	2735	7
42	2782	2788	2795	2802	2809	2815	7
43	2863	2870	2877	2884	2891	2897	7
44	2946	2953	2960	2967	2974	2981	7
45	3030	3037	3044	3051	3058	3065	7
46	3116	3123	3130	3137	3144	3152	7
47	3203	3210	3217	3225	3232	3240	8
48	3292	3299	3006	3314	3322	3329	8
49	3382	3390	3397	3405	3413	3420	8
50	3474	3482	3490	3498	3506	3514	8
51	3569	3577	3585	3593	3601	3609	8
52	3665	3673	3681	3690	3698	3706	8
53	3764	5772	3780	3789	3797	3806	8
54	3865	3873	3882	3890	3899	3907	8
55	3968	3977	3985	3994	4003	4012	9
56	4074	4083	4092	4101	4110	4119	9
57	4183	4192	4201	4210	4220	4229	9
58	4294	4304	4313	4323	4332	4342	10
59	4409	4419	4429	4438	4448	4458	10

The Deg. of Lat.	*The Minutes of each Degree.*						The Difference
	30*m.*	35*m.*	40*m*	45*m*	50*m.*	55*m*	
	The Meridional Parts.						
30	1923	1929	1935	1941	1946	1952	6
31	1993	1999	2005	2011	2017	2022	6
32	2064	2070	2076	2082	2088	2094	6
33	2135	2141	2147	2153	2159	2165	6
34	2208	2214	2220	2226	2232	2238	6
35	2281	2287	2293	2299	2306	2312	6
36	2355	2363	2368	2374	2380	2386	6
37	2430	2437	2443	2449	2456	2462	6
38	2506	2513	2519	2526	2532	2538	6
39	2584	2590	2597	2603	2610	2616	6
40	2662	2669	2675	2682	2688	2695	6
41	2742	2748	2755	2762	2768	2775	7
42	2822	2829	2836	2843	2849	2856	7
43	2904	2911	2918	2925	2932	2939	7
44	2988	2995	3002	3009	3016	3023	7
45	3073	3080	3087	3094	3101	3108	7
46	3159	3166	3173	3181	3188	3195	7
47	3247	3254	3262	3269	3277	3284	8
48	3337	3344	3352	3359	3367	3374	8
49	3428	3436	3443	3451	3459	3467	8
50	3521	3529	3537	3545	3553	3560	8
51	3617	3625	3633	3641	3649	3657	8
52	3714	3722	3731	3739	3747	3755	8
53	3814	3822	3831	3839	3848	3856	8
54	3916	3925	3933	3942	3951	3959	8
55	4021	4029	4038	4047	4056	4065	9
56	4128	4137	4146	4155	4164	4173	9
57	4238	4247	4257	4266	4275	4285	9
58	4351	4361	4370	4380	4390	4399	10
59	4468	4478	4488	4497	4507	4517	10

The Deg. of Lat.	*The Minutes of each Degree*						The Difference
	0*m.*	5*m.*	10*m.*	15*m.*	20*m.*	25*m.*	
	The Meridional Parts						
60	4527	4537	4547	4557	4508	4578	10
61	4649	4660	4670	4680	4691	4701	10
62	4775	4786	4796	4807	4818	4829	11
63	4905	4916	4927	4938	4949	4960	11
64	5039	5051	5062	5074	5085	5097	12
65	5179	5191	5203	5214	5226	5238	12
66	5324	5336	5348	5361	5373	5385	12
67	5474	5487	5500	5513	5526	5539	13
68	5631	5644	5658	5671	5685	5698	13
69	5795	5809	5823	5837	5851	5865	14
70	5966	5981	5995	6010	6025	6040	15
71	6146	6161	6177	6192	6208	6223	15
72	6335	6351	6367	6384	6400	6417	16
73	6534	6552	6569	6586	6603	6621	17
74	6746	6764	6782	6801	6819	6838	18
75	6970	6990	7009	7029	7048	7068	20
76	7210	7231	7252	7273	7294	7315	21
77	7467	7490	7512	7535	7557	7580	23
78	7745	7769	7793	7817	7842	7867	25
79	8046	8072	8099	8125	8152	8179	27
80	8375	8404	8433	8463	8492	8522	30
81	8739	8771	8803	8836	8869	8903	33
82	9145	9182	9218	9255	9292	9330	37
83	9606	9647	9689	9731	9774	9817	43
84	10137	10185	10234	10283	10334	10385	51
85	10765	10822	10881	10941	11002	11064	62
86	11533	11605	11679	11755	11832	11911	77
87	12521	12619	12179	12821	12927	13036	109
88	13916	14063	14216	14376	14543	14720	
89	16300	16599	16926	17289	17693	18153	

The Deg. of Lat.	The Minutes of each Degree.						The Difference
	30m.	35m.	40m.	45m.	50m.	55m.	
	The Meridional Parts						
60	4588	4598	4608	4618	4629	4639	10
61	4712	4722	4733	4743	4754	4764	10
62	4839	4850	4861	4872	4883	4894	11
63	4972	4983	4994	5005	5017	5028	11
64	5108	5120	5132	5143	5155	5167	12
65	5250	5263	5275	5287	5299	5311	12
66	5398	5411	5423	5436	5449	5461	12
67	5552	5565	5578	5592	5604	5617	13
68	5712	5725	5739	5753	5767	5781	14
69	5879	5894	5908	5922	5937	5951	14
70	6055	6070	6085	6100	6115	6130	15
71	6239	6255	6271	6287	6303	6319	16
72	6433	6450	6467	6483	6500	6517	17
73	6639	6656	6674	6692	6710	6728	18
74	6856	6875	6894	6913	6932	6951	19
75	7088	7108	7128	7149	7169	7189	20
76	7336	7358	7379	7401	7423	7445	22
77	7603	7626	7650	7673	7697	7722	24
78	7892	7917	7942	7968	7994	8020	26
79	8207	8234	8232	8290	8318	8347	28
80	8552	8583	8614	8644	8976	8707	31
81	8936	8970	9005	9039	9074	9110	36
82	9368	9407	9445	9485	9525	9565	40
83	9861	9906	9951	9996	10043	10089	46
84	10437	10489	10542	10597	10652	10707	55
85	11127	11192	11257	11324	11392	11462	68
86	11992	12075	12160	12247	12336	12428	89
87	13149	13266	13386	13511	13641	13776	
88	14906	15102	15311	15532	15770	16024	
89	18683	19309	20076	21065	22459	24842	

D.	1	2	3	4
5	1	2	3	4
6	1	2	3	5
7	1	3	4	6
8	2	3	5	6
9	2	4	5	7
10	2	4	6	8
11	2	4	7	9
12	2	5	7	10
13	3	5	8	10
14	3	6	8	11
15	3	6	9	12
16	3	6	10	13
17	3	7	10	14
18	4	7	11	14
19	4	8	11	15
20	4	8	12	16
21	4	8	13	17
22	4	9	13	18
23	5	9	14	18
24	5	10	14	19

D.	1	2	3	4
25	5	10	15	20
26	5	10	16	21
27	5	11	16	22
28	6	11	17	22
30	6	12	18	24
31	6	12	19	25
33	7	13	20	26
35	7	14	21	28
37	7	15	22	30
40	8	16	24	32
42	8	17	25	34
46	9	18	28	37
50	10	20	30	40
55	11	22	33	44
61	12	24	37	49
68	14	27	41	54
76	15	30	46	61
88	18	35	53	70
105	21	63	53	84
115	23	69	69	92

A

A Table of *Logarithms*

For Numbers increaſing in their Natural Order, from an Unit to 10,000.

With a TABLE of Artificial SINES, TANGENTS, and SECANTS, the RADIUS 10,000000; and to every Degree and Minute of the *Quadrant*.

N.	Logar.	N.	Logar.	N	Logar.
1	0.000000	34	1.531479	67	1.826075
2	0.301030	35	1.544068	68	1.832509
3	0.477121	36	1.556302	69	1.838849
4	0.602060	37	1.568202	70	1.845098
5	0.698970	38	1.579784	71	1.851258
6	0.778151	39	1.591065	72	1.857332
7	0.845098	40	1.602060	73	1.863323
8	0.903090	41	1.612784	74	1.864232
9	0.954242	42	1.623249	75	1.875061
10	1.000000	43	1.633468	76	1.880814
11	1.041393	44	1.643453	77	1.886491
12	1.079181	45	1.653212	78	1.892095
13	1.113943	46	1.662758	79	1.897627
14	1.146128	47	1.672098	80	1.903090
15	1.176091	48	1.681241	81	1.908485
16	1.204120	49	1.690196	82	1.913814
17	1.230449	50	1.698970	83	1.919078
18	1.255272	51	1.707570	84	1.924279
19	1.278754	52	1.716003	85	1.929419
20	1.301030	53	1.724276	86	1.934498
21	1.322219	54	1.732394	87	1.939519
22	1.342423	55	1.740363	88	1.944483
23	1.361728	56	1.748188	89	1.949390
24	1.380211	57	1.755875	90	1.954242
25	1.397940	58	1.763428	91	1.959041
26	1.414973	59	1.770852	92	1.963788
27	1.431364	60	1.778151	93	1.968483
28	1.447158	61	1.785330	94	1.973128
29	1.462398	62	1.792392	95	1.977724
30	1.477121	63	1.799340	96	1.982271
31	1.491362	64	1.806180	97	1.986772
32	1.505150	65	1.812913	98	1.991226
33	1.518514	66	1.819544	99	1.995635

Num	0	1	2	3	4	*Diff*
100	2.000000	2.000434	2.000868	2.001301	2.001724	434
101	2.004321	2.004751	2 005180	2.005609	2.006038	428
102	2.008600	2.009026	2.009451	2.009876	2.010300	424
103	2.012837	2.013256	2.013680	2.014100	2.014520	419
104	2.017033	2.017451	2.017868	2.018284	2.018700	416
105	2.021189	2.021603	2.022016	2.022428	2.022841	412
106	2.025306	2.025715	2.026124	2.026533	2.026942	408
107	2.029384	2.029789	2.030195	2.030600	2.031004	404
108	2.033424	2.033826	2.034227	2.034628	2.035029	400
109	2.037426	2 037825	2.038223	2.038620	2.039017	396
110	2.041393	2.041787	2.042182	2.042575	2.042969	393
111	2.045323	2.045714	2.046105	2.046495	2.046885	389
112	2.049218	2.049606	2.049993	2.050380	2.050766	386
113	2.053078	2.053463	2.053846	2.054230	2.054613	382
114	2.056905	2.057286	2.057666	2.058046	2.058426	379
115	2.060698	2.061075	2.061452	2.061829	2.062206	376
116	2.064458	2.064832	2.065206	2.065580	2.065953	372
117	2.068186	2.068557	2.068928	2.069298	2.069668	369
118	2.071882	2.072250	2.072617	2.072985	2.073352	366
119	2.075547	2.075912	2.076276	2.076640	2.077004	363
120	2.079181	2.079543	2.079904	2.080266	2.080626	360
121	2.082785	2.083144	2.083503	2.083861	2.084219	357
122	2.086360	2.086716	2.087071	2.087426	2.087781	355
123	2.089905	2.090258	2.090611	2.090963	2.091315	351
124	2.093422	2.093772	2.094122	2.094471	2.094820	349
125	2.096910	2.097257	2.097604	2.097951	2.098297	346
126	2.100370	2.100715	2.101059	2.101403	2.101747	343
127	2.103804	2.104145	2.104487	2.104828	2.105169	340
128	2.107210	2.107549	2.107888	2.108227	2.108565	338
129	2.110590	2.110926	2.111262	2.111598	2.111934	335
130	2.113943	2.114277	2.114611	2.114944	2.115278	333
131	2.117271	2.117603	2.117934	2.118265	2.118595	330
132	2.120574	2.120903	2,121231	2,121560	2.121888	328
133	2.123852	2.124178	2.124504	2.124830	2.125156	325
134	2.127105	2.127429	2.127752	2.128076	2,128399	323
135	2.130334	2.130655	2.130977	2.131298	2.131619	321
136	2.133539	2.133858	2.134177	2.134496	2.134814	318
137	2.136721	2.137037	2.137354	2.137670	2.137987	315
138	2.139879	2.140194	2.140508	2,140822	2 141136	314
139	2.143015	2.143327	2,143639	2.143951	2.144263	312
140	2.146128	2.146438	2.146748	2.147058	2.147367	309
141	2.149219	2.149527	2.149835	2.150142	2.150449	307
142	2.152288	2.152594	2.152900	2.153205	2.153510	305

Num	5	6	7	8	9	*Diff.*
100	2.002166	2.002598	2.003029	2.003461	2.003891	432
101	2.006466	2.006894	2.007321	2.007748	2.008174	428
102	2.010724	2.011147	2.011570	2.011993	2.012415	424
103	2.014940	2.015360	2.015779	2.016198	2.016615	419
104	2.019116	2.019532	2.019947	2.020361	2.020775	416
105	2.023252	2.023664	2.024075	2.024486	2.024896	412
106	2.027350	2.027757	2.028164	2.028571	2.028978	408
107	2.031408	2.031812	2.032216	2.032619	2.033021	404
108	2.035430	2.035830	2.036229	2.036629	2.037028	400
109	2.039414	2.039811	2.040207	2.040602	2.040998	396
110	2.043362	2.043755	2.044148	2.044540	2.044931	393
111	2.047275	2.047664	2.048053	2.048442	2.048830	389
112	2.051152	2.051538	2.051924	2.052309	2.052694	386
113	2.054996	2.055378	2.055760	2.056142	2.056524	382
114	2.058805	2.059185	2.059563	2.059942	2.060320	379
115	2.062582	2.062958	2.063333	2.063709	2.064083	376
116	2.066326	2.066699	2.067071	2.067443	2.067814	372
117	2.070038	2.070407	2.070776	2.071145	2.071514	369
118	2.073718	2.074085	2.074451	2.074816	2.075182	366
119	2.077368	2.077731	2.078094	2.078457	2.078819	363
120	2.080987	2.081347	2.081707	2.082067	2.082426	360
121	2.084576	2.084934	2.085291	2.085647	2.086004	357
122	2.088136	2.088490	2.088845	2.089198	2.089552	355
123	2.091667	2.092018	2.092370	2.092721	2.093071	351
124	2.095169	2.095518	2.095866	2.096215	2.096562	349
125	2.098644	2.098990	2.099335	2.099681	2.100026	346
126	2.102090	2.102434	2.102777	2.103119	2.103462	343
127	2.105510	2.105851	2.106191	2.106531	2.106870	340
128	2.108903	2.109241	2.109578	2.109916	2.110253	338
129	2.112270	2.112605	2.112940	2.113275	2.113609	335
130	2.115610	2.115943	2.116276	2.116608	2.116940	333
131	2.118926	2.119256	2.119586	2.119915	2.120245	330
132	2.122216	2.122543	2.122871	2.123198	2.123525	328
133	2.125481	2.125806	2.126131	2.126456	2.126781	325
134	2.128722	2.129045	2.129368	2.129690	2.130012	322
135	2.131939	2.132260	2.132580	2.132900	2.133219	320
136	2.135133	2.135451	2.135768	2.136086	2.136403	318
137	2.138303	2.138618	2.138934	2.139249	2.139564	315
138	2.141450	2.141763	2.142076	2.142389	2.142702	314
139	2.144574	2.144885	2.145196	2.145507	2.145818	311
140	2.147676	2.147985	2.148294	2.148603	2.148911	309
141	2.150756	2.151063	2.151370	2.151676	2.151982	306
142	2.153815	2.154119	2.154424	2.154728	2.155032	304

Num	0	1	2	3	4	*Diff*
143	2.155336	2.155640	2.155943	2.156246	2.156549	303
144	2.158362	2.158664	2.158965	2.159266	2.159567	301
145	2.161368	2.161667	2.161967	2.162266	2.162564	299
146	2.164353	2.164650	2.164947	2.165244	2.165541	297
147	2.167317	2.167613	2.167908	2.168203	2.168497	295
148	2.170262	2.170555	2.170848	2.171141	2.171434	293
149	2.173186	2.173478	2.173768	2.174060	2.174351	291
150	2.176091	2.176381	2.176670	2.176959	2.177248	289
151	2.178977	2.179264	2.179552	2,179839	2.180126	287
152	2.181844	2.182129	2.182415	2.182700	2.182985	285
153	2.184691	2.184975	2.185259	2,185542	2.185825	283
154	2.187521	2.187803	2.188084	2.188366	2.188647	281
155	2.190332	2.190612	2.190892	2.191171	2.191451	279
156	2.193125	2.193403	2.193681	2.193959	2.194237	278
157	2.195900	2.196176	2.196452	2.196729	2.197005	276
158	2.198657	2.198932	2.199206	2.199481	2.199755	274
159	2.201357	2.201670	2.201943	2.202216	2.202488	272
160	2.204120	2.204391	2.204662	2.204933	2.205204	271
161	2.206826	2.207095	2.207365	2.207634	2.207903	269
162	2.209515	2.209783	2.210051	2.210318	2.210586	267
163	2.212188	2.212454	2.212720	2.212986	2.213252	266
164	2.214844	2.215109	2.215373	2.215638	2.215902	264
165	2.217484	2.217747	2.218010	2.218273	2.218535	262
166	2.220108	2.220370	2.220631	2.220892	2.221153	261
167	2.222716	2.222976	2.323236	2.223496	2.222755	259
168	2.225309	2.225568	2.225826	2.226084	2.226342	258
169	2.227887	2.228144	2.228400	2.228657	2.228913	256
170	2.230449	2.230704	2.230960	2.231215	2.231470	254
171	2.232996	2.233250	2.233504	2.233757	2.234011	253
172	2.235528	2.235781	2.236033	2.236285	2.236537	252
173	2.238046	2.238297	2.238548	2.238799	2.239049	250
174	2.240549	2.240799	2.241048	2.241297	2.241546	249
175	2.243038	2.243286	2,243534	2.243782	2.240030	248
176	2.245513	2.245759	2.246006	2.246252	2.246499	246
177	2.247973	2.248219	2.248464	2.248709	2.248954	245
178	2.250420	2.250664	2.250908	2.251151	2.251395	243
179	2.252853	2.253096	2.253338	2.253580	2.253822	242
180	2.255272	2.255514	2.255755	2.255996	2.256237	241
181	2.257679	2.257918	2,258158	2.258398	2.258637	239
182	2.260071	2.260310	2.260548	2.260787	2.261025	232
183	2.262451	2.262688	2.262925	2.263162	2.263399	237
184	2.264818	2.265054	2.265290	2.265525	2.265761	235
185	2.267172	2.267406	2.267641	2.267875	2.268110	234

Num.	5	6	7	8	9	Diff.
143	2.156852	2.157154	2.157457	2.157759	2.158061	302
144	2.159868	2.160168	2.160468	2.160769	2.161068	301
145	2.162863	2.163161	2.163460	2.163757	2.164055	299
146	2.165838	2.166134	2.166430	2.166726	2.167022	297
147	2.168792	2.169086	2.169380	2.169674	2.169968	295
148	2.171726	2.172019	2.172311	2.172603	2.172895	292
149	2.174641	2.174932	2.175222	2.175512	2.175802	291
150	2.177536	2.177825	2.178113	2.178401	2.178689	289
151	2.180413	2.180699	2.180986	2.181272	2.181558	287
152	2.183270	2.183554	2.183839	2.184123	2.184407	285
153	2.186108	2.186391	2.186674	2.186956	2.187239	283
154	2.188928	2.189219	2.189490	2.189771	2.190051	281
155	2.191730	2.192010	2.192289	2.192567	2.192846	279
156	2.194514	2.194792	2.195069	2.195346	2.195623	278
157	2.197281	2.197556	2.197832	2.198107	2.198382	276
158	2.200029	2.200303	2.200577	2.200850	2.201124	274
159	2.202761	2.203033	2.203305	2.203577	2.203848	272
160	2.205475	2.205745	2.206016	2.206286	2.206556	271
161	2.208172	2.208441	2.208710	2.208978	2.209247	269
162	2.210853	2.211120	2.211388	2.211654	2.211921	267
163	2.213518	2.213783	2.214049	2.214314	2.214579	266
164	2.216166	2.216430	2.216694	2.216957	2.217221	264
165	2.218798	2.219060	2.219322	2.219584	2.219846	262
166	2.221414	2.221675	2.221936	2.222196	2.222456	261
167	2.224015	2.224274	2.224533	2.224792	2.225051	259
168	2.226600	2.226858	2.227115	2.227372	2.227630	258
169	2.229170	2.229426	2.229682	2.229938	2.230193	256
170	2.231724	2.231979	2.232233	2.232488	2.232742	254
171	2.234264	2.234517	2.234770	2.235023	2.235276	253
172	2.236789	2.237041	2.237292	2.237544	2.237795	251
173	2.239299	2.239550	2.239800	2.240050	2.240300	250
174	2.241795	2.242044	2.242293	2.242541	2.242790	249
175	2.244277	2.244524	2.244772	2.245019	2.245266	248
176	2.246745	2.246991	2.247236	2.247482	2.247728	246
177	2.249198	2.249443	2.249687	2.259932	2.250176	245
178	2.251638	2.251881	2.252125	2.252367	2.252610	243
179	2.254064	2.254306	2.254548	2.254790	2.255031	242
180	2.256477	2.256718	2.256958	2.257198	2.257439	241
181	2.258877	2.259116	2.259355	2.259594	2.259833	239
182	2.261263	2.261501	2.261738	2.261976	2.262214	238
183	2.263636	2.263873	2.264109	2.264345	2.265582	237
184	2.265996	2.266232	2.266467	2.266702	2.266937	235
185	2.268344	2.268578	2.268812	2.269045	2.269279	234

A Table of Logarithms

Num.	0	1	2	3	4	Diff
186	2.269513	2.269746	2.269980	2.270213	2.270446	233
187	2.271842	2.272074	2.272306	2.272538	2.272770	232
188	2.274158	2.274389	2.274620	2.274850	2.275081	230
189	2.276462	2.276691	2.276921	2.277151	2.277380	229
190	2.278754	2.278982	2.279210	2.279439	2.279667	228
191	2.281033	2.281261	2.281488	2.281715	2.281942	227
192	2.283301	2.283527	2.283753	2.283979	2.284205	225
193	2.285557	2.285782	2.286007	2.286232	2.286456	225
194	2.287802	2.288025	2.288249	2.288473	2.288696	223
195	2.290035	2.290257	2.290480	2.290702	2.290925	222
196	2.292256	2.292478	2.292699	2.292920	2.293141	221
197	2.294466	2.294687	2.294907	2.295127	2.295347	220
198	2.296665	2.296884	2.297104	2.297323	2.297542	219
199	2.298853	2.299071	2.299289	2.299507	2.299725	218
200	2.301030	2.301247	2.301464	2.301681	2.301898	217
201	2.303196	2.303412	2.303628	2.303844	2.304059	216
202	2.305351	2.305566	2.305781	2.305996	2.306210	215
203	2.307496	2.307710	2.307924	2.308137	2.308351	213
204	2.309630	2.309843	2.310056	2.310268	2.310481	212
205	2.311754	2.311966	2.312177	2.312389	2.312600	211
206	2.313867	2.314078	2.314289	2.314499	2.314710	210
207	2.315970	2.316180	2.316390	2.316599	2.316809	209
208	2.318063	2.318272	2.318481	2.318689	2.318898	208
209	2.320146	2.320354	2.320562	2.320769	2.320977	207
210	2.322219	2.322426	2.322633	2.322839	2.323046	206
211	2.324282	2.324488	2.324694	2.324899	2.325105	205
212	2.326336	2.326541	2.326745	2.326950	2.327154	204
213	2.328380	2.328583	2.328787	2.328991	2.329194	203
214	2.330414	2.330617	2.330819	2.331022	2.331225	202
215	2.332438	2.332640	2.332842	2.333044	2.333246	202
216	2.334454	2.334655	2.334856	2.335056	2.335257	201
217	2.336460	2.336660	2.336860	2.337060	2.337260	200
218	2.338456	2.338656	2.338855	2.339054	2.339253	199
219	2.340444	2.340642	2.340840	2.341039	2.341237	198
220	2.342423	2.342620	2.342817	2.343014	2.343212	197
221	2.344392	2.344589	2.344785	2.344981	2.345178	196
222	2.346353	2.346549	2.346744	2.346939	2.347135	195
223	2.348305	2.348500	2.348694	2.348889	2.349083	194
224	2.350248	2.350442	2.350636	2.350829	2.351023	193
225	2.352182	2.352375	2.352568	2.352761	2.352954	193
226	2.354108	2.354301	2.354493	2.354684	2.354876	192
227	2.356026	2.356217	2.356408	2.356599	2.356790	191
228	2.357935	2.358125	2.358316	2.358506	2.358696	190

Num.	5	6	7	8	9	*Diff*
186	2.270679	2.270912	2.271144	2.271377	2.271609	233
187	2.273001	2.273233	2.273464	2.273696	2.273927	232
188	2.275311	2.275544	2.275772	2.276002	2.276232	230
189	2.277609	2.277838	2.278067	2.278296	2.278525	229
190	2.279895	2.280123	2.280351	2.280578	2.280806	228
191	2.282169	2.282395	2.282622	2.282849	2.283075	227
192	2.284431	2.284656	2.284882	2.285107	2.285332	226
193	2.286681	2.286905	2.287130	2.287354	2.287578	225
194	2.288920	2.289143	2.289366	2.289589	2.289812	223
195	2.291147	2.291369	2.291591	2.291813	2.292034	222
196	2.293362	2.293583	2.293804	2.294025	2.294246	221
197	2.295567	2.295787	2.296007	2.296226	2.296446	220
198	2.297760	2.297979	2.298198	2.298416	2.298635	219
199	2.299943	2.300160	2.300378	2.300595	2.300813	218
200	2.302114	2.302331	2.302547	2.302764	2.302980	217
201	2.304275	2.304490	2.304706	2.304921	2.305136	216
202	2.306425	2.306639	2.306854	2.307068	2.307282	215
203	2.308564	2.308778	2.308991	2.309204	2.309417	213
204	2.310693	2.310906	2.311118	2.311330	2.311542	212
205	2.312812	2.313023	2.313234	2.313445	2.313656	211
206	2.314920	2.315130	2.315340	2.315550	2.315766	210
207	2.317018	2.317227	2.317436	2.317645	2.317854	209
208	2.319106	2.319314	2.319522	2.319730	2.319938	208
209	2.321184	2.321391	2.321598	2.321805	2.322012	207
210	2.323252	2.323458	2.323664	2.323871	2.324077	206
211	2.325310	2.325516	2.325721	2.325926	2.326131	205
212	2.327359	2.327563	2.327767	2.327972	2.328176	204
213	2.329398	2.329601	2.329804	2.330008	2.330211	203
214	2.331427	2.331630	2.331832	2.332034	2.332236	202
215	2.333447	2.333649	2.333850	2.334051	2.334253	202
216	2.335458	2.335658	2.335859	2.336059	2.336259	201
217	2.337459	2.337659	2.337858	2.338058	2.338257	200
218	2.339451	2.339650	2.339849	2.340047	2.340246	199
219	2.341434	2.341632	2.341830	2.342028	2.342225	198
220	2.343409	2.343605	2.343802	2.343999	2.344196	197
221	2.345327	2.345570	2.345766	2.345961	2.346117	196
222	2.347330	2.347525	2.347720	2.347915	2.348110	195
223	2.349277	2.349472	2.349666	2.349860	2.350054	194
224	2.351216	2.351410	2.351603	2.351796	2.351989	193
225	2.353146	2.353239	2.353532	2.353724	2.353916	193
226	2.355068	2.355260	2.355451	2.355643	2.355834	192
227	2.356981	2.357172	2.357363	2.357554	2.357744	191
228	2.358886	2.359076	2.359266	2.359456	2.359640	190

Num.	0	1	2	3	4	*Diff*
229	2.359835	2.360025	2.360215	2.360404	2.360593	189
230	2.361728	2.361917	2.362105	2.362294	2.362482	188
231	2.363612	2.363800	2.363988	2.364176	2.364363	188
232	2.365488	2.365675	2.365862	2.366049	2.366236	187
233	2 367356	2.367542	2.367728	2.367915	2.368101	186
234	2.369216	2.369401	2.369587	2.369772	2.369958	185
235	2.371068	2.371253	2.371437	2.371622	2.371806	184
236	2.372912	2.373096	2.373280	2.373464	2.373647	184
237	2.374748	2.374932	2.375115	2.375298	2.375481	183
238	2.376577	2,376759	2.376942	2.377124	2.377306	182
239	2.378398	2.378580	2.378761	2.378943	2.379124	181
240	2.380211	2,380392	2,380573	2.380754	2.380934	181
241	2.382017	2.382197	2.382377	2.382557	2.382737	180
242	2.383815	2.383995	2.384174	2.384353	2,384533	179
243	2.385606	2.385785	2.385964	2.386142	2.386321	178
244	2.387390	2.387568	2.387746	2.387923	2.388101	178
245	2.389166	2.389343	2.389520	2.389697	2.389874	177
246	2.390935	2.391113	2.391288	2.391464	2,391641	176
247	2.392697	2.392873	2.393048	2.393224	2.393400	176
248	2.394452	2.394627	2.394802	2.394977	2.395152	175
249	2.396199	2.396374	2.396548	2.396722	2.396896	174
250	2.397940	2.398114	2.398287	2.398461	2.398634	173
251	2.399674	2 399847	2.100020	2.400192	2.400365	173
252	2 401400	2.401573	2.401745	2.401917	2.402089	172
253	2.403120	2.403292	2.403464	2.403635	2.403807	171
254	2.404834	2.405005	2.405175	2.405346	2.405517	171
255	2-406540	2.406710	2.406881	2.407051	2.407221	170
256	2 408240	2.408409	2.408579	2.408749	2.408918	169
257	2.409933	2 410102	2.410271	2.410440	2.410608	169
258	2.411620	2.411788	2.411956	2.412124	2.412292	168
259	2.413300	2.413467	2.413635	2.413802	2.413970	167
260	2.414973	2.415140	2.415307	2.415474	2,415641	167
261	2.416640	2.416807	2.416973	2.417139	2 417306	166
262	2.418301	2.418467	2.418633	2.418798	2.418964	165
263	2.419956	2.420121	2.420286	2.420451	2.420616	165
264	2.421604	2.421768	2.421933	2.422097	2.422261	164
265	2.423246	2.423410	2.423573	2.423737	2.423901	164
266	2.424882	2 425045	2 425208	2,425371	2.425534	163
267	2.426511	2.426674	2.426836	2.426999	2.427161	162
268	2.428135	2.428297	2.428459	2.428621	2.428782	162
269	2.429752	2.429914	2.430075	2.430236	2.430398	161
270	2.431364	2.431525	2.431685	2.431846	2.432007	161
271	2.432969	2.433129	2.433290	2.433450	2 433610	160

Num	5	6	7	8	9	*Diff.*
229	2.360783	2.360972	2.361161	2.361350	2.361539	189
230	2.362671	2.362859	2.363048	2.363236	2.363424	188
231	2.364551	2.364739	2.364926	2.365113	2.365301	188
232	2.366423	2.366610	2.366796	2.366983	2.367169	187
233	2.368287	2.368473	2.368659	2.368844	2.369030	186
234	2.370143	2.370328	2.370513	2.370698	2.370883	185
235	2.371991	2.372175	2.372360	2.372544	2.372728	184
236	2.373831	2.374015	2.374198	2.374382	2.374565	184
237	2.375664	2.375846	2.376029	2.376212	2.376394	183
238	2.377488	2.377670	2.377852	2.378034	2.378216	182
239	2.379305	2.379487	2.379668	2.379849	2.380030	181
240	2.381115	2.381296	2.381476	2.381656	2.381837	181
241	2.382917	2.383097	2.383277	2.383456	2.383636	180
242	2.384712	2.384891	2.385070	2.385249	2.385427	179
243	2.386499	2.386677	2.386855	2.387034	2.387212	178
244	2.388279	2.388456	2.388634	2.388811	2.388989	178
245	2.390051	2.390228	2.390405	2.390582	2.390758	177
246	2.391817	2.391993	2.392169	2.392345	2.392521	176
247	2.393575	2.393751	2.393926	2.394101	2.394276	176
248	2.395326	2.395501	2.395676	2.395850	2.396025	175
249	2.397070	2.397245	2,397418	2.397592	2.397766	174
250	2.398808	2.398981	2.399154	2.399327	2.399501	173
251	2.400538	2.400711	2.400883	2.401056	2.401228	173
252	2.402261	2.402433	2.402605	2.402777	2.402949	172
253	2.403978	2.404149	2.404320	2.404492	2.404663	171
254	2.405688	2.405858	2.406029	2.406199	2.406370	171
255	2.407391	2.407561	2.407731	2.407900	2.408070	170
256	2.409087	2.409257	2.409426	2.409595	2.409764	169
257	2.410777	2.410946	2.411114	2.411283	2.411451	169
258	2.412460	2.412628	2.412796	2.412964	2.413132	168
259	2.414137	2.414305	2.414472	2.414639	2.414806	167
260	2.415808	2.415974	2.416141	2.416308	2.416474	167
261	2.417472	2.417638	2.417804	2.417970	2.418135	166
262	2.419129	2.419295	2.419460	2.419625	2.419191	165
263	2.420781	2.420945	2.421110	2.421275	2.421439	165
264	2.422426	2.422590	2.422754	2.422918	2.423082	164
265	2.424064	2.424228	2.424392	2.424555	2.424718	163
266	2.425697	2.425860	2.426023	2.426186	2.420349	163
267	2.427324	2.427486	2.427648	2.427811	2.427973	162
268	2.428944	2.429106	2.429268	2.429429	2.429591	162
269	2.430559	2.430720	2.430881	2.431042	2.431203	161
270	2.432167	2.432328	2.432488	2.432649	2.432809	160
271	2.433770	2.433930	2.434090	2.434249	2.434409	16

Num	0	1	2	3	4	*Diff*
272	2.434569	2.434728	2.434888	2.435048	2.435207	159
273	2.436163	2.436322	2 436481	2.436640	2.436798	159
274	2.437751	2.437909	2.438067	2.438226	2.438384	158
275	2.439333	2.439491	2.439648	2.439806	2.439964	158
276	2.440909	2.441066	2.441224	2.441381	2.441538	157
277	2.442480	2.442636	2.442793	2.442950	2.443106	157
278	2.444045	2.444201	2.444357	2.444513	2.444669	156
279	2.445604	2.445760	2.445915	2.446071	2.446226	155
280	2.447158	2.447313	2.447468	2.447623	2.447778	155
281	2.448706	2.448861	2.449015	2.449170	2.449324	154
282	2.450249	2.450403	2.450557	2.450711	2.450865	154
283	2.451786	2.451940	2.452093	2.452247	2.452400	153
284	2.453318	2.453471	2.453624	2.453777	2.453930	153
285	2.454845	2.454997	2.455149	2.455302	2.455454	152
286	2.456366	2.456518	2.456670	2.456821	2.456973	152
287	2.457882	2.458033	2.458184	2.458336	2.458487	151
288	2.459392	2.459543	2.459694	2.459845	2.459995	151
289	2.460898	2.461048	2.461198	2.461348	2.461498	150
290	2.462398	2.462548	2.462697	2.462847	2.462997	150
291	2.463893	2.464042	2.464191	2.464340	2.464489	149
292	2.465383	2.465532	2.465680	2.465829	2.465977	149
293	2.466863	2.467016	2.467164	2.467312	2.467460	148
294	2.468347	2.468495	2.468643	2.468790	2.468938	147
295	2.469822	2.469969	2.470116	2.470263	2.470410	147
296	2.471292	2.471438	2.471585	2.471732	2.471878	146
297	2.472756	2.472903	2.473049	2.473195	2.473341	146
298	2.474216	2.474362	2.474508	2.474653	2.474799	145
299	2.475671	2.475816	2.475962	2.476107	2.476252	145
300	2.477121	2.477266	2.477411	2.477555	2.477700	145
301	2.478566	2.478711	2.478855	2.478999	2.479143	144
302	2.480007	2.480151	2.480294	2.480438	2.480582	144
303	2.481443	2.481586	2.481729	2.481872	2.482016	143
304	2.482874	2.483016	2.483159	2.483302	2.483445	143
305	2.484300	2.484442	2.484584	2.484727	2.484869	142
306	2.485721	2.485863	2 486005	2.486147	2.486289	142
307	2.487138	2.487280	2.487421	2,487563	2.487704	141
308	2.488551	2.488692	2,488833	2.488973	2.489114	141
309	2.489958	2.490099	2.490239	2.490380	2.490520	140
310	2.491362	2.491502	2.491642	2,491782	2.491922	140
311	2.492760	2.492900	2 493040	2.493179	2.493319	139
312	2.494155	2.494294	2.494433	2.494572	2.494711	139
313	2.495544	2.495683	2.495822	2.495960	2.496099	139
314	2.496930	2.497068	2.497206	2.497344	2.497482	138

Num	5	6	7	8	9	*Diff*
272	2.435366	2.435526	2.435685	2.435844	2.436003	159
273	2.436957	2.437116	2.437275	2.437433	2.437592	159
274	2.438542	2.438700	2.438859	2.439017	2.439175	158
275	2.440122	2.440279	2.440437	2.440594	2.440752	158
276	2.441695	2.441852	2.442009	2.442166	2.442323	157
277	2.443263	2.443419	2.443576	2.443732	2.443888	157
278	2.444825	2.444981	2.445137	2.445293	2.445448	156
279	2.446382	2.446537	2.446692	2.446848	2.447003	155
280	2.447933	2.448088	2.448242	2.448397	2.448552	155
281	2.449478	2.449633	2.449787	2.449941	2.450095	154
282	2.451018	2,451172	2.451325	2.451479	2.451633	154
283	2.452553	2.452706	2.452859	2.453012	2.453165	153
284	2.454082	2.454235	2.454387	2.454540	2.454692	153
285	2.455606	2.455758	2.455910	2.456062	2.456214	152
286	2.457125	2.457276	2.457428	2.457579	2.457730	152
287	2.458638	2.458789	2.458940	2.459091	2.459242	151
288	2.460146	2.460296	2.460447	2.460597	2.460747	151
289	2.461649	2.461799	2.461948	2.462098	2.462248	150
290	2.463146	2.463296	2.463445	2.463594	2.463744	150
291	2.464639	2.464787	2.464936	2.465085	2.465234	149
292	2.466126	2.466274	2,466423	2.466571	2.466719	149
293	2.467608	2.467756	2.467904	2.468052	2.468200	148
294	2.469085	2.469233	2.469380	2.469527	2.469675	147
295	2.470557	2.470704	2.470851	2.470998	2.471145	147
296	2.472025	2.472171	2.472317	2.472464	2.472610	146
297	2.473487	2.473633	2.473779	2.473925	2.474070	146
298	2.474944	2.475090	2.475235	2.475381	2.475526	146
299	2.476397	2.476542	2.476687	2.476832	2.476976	145
300	2.477844	2.477989	2.478133	2.478278	2.478422	145
301	2.479287	2.479431	2.479575	2.479719	2.479863	144
302	2.480725	2.480869	2.481012	2.481156	2.481299	144
303	2.482159	2.482302	2.482445	2.482588	2.482731	143
304	2.483587	2.483730	2.483872	2.484015	2.484157	143
305	2.485011	2.485153	2.485295	2.485437	2.485579	142
306	2.486430	2.486572	2.486714	2.486855	2.486997	142
307	2.487845	2.487986	2.488127	2.488269	2.488410	141
308	2.489255	2.489396	2.489537	2.489677	2.489818	141
309	2.490661	2.490801	2.490941	2.491081	2.491222	140
310	2.492062	2.492201	2.492341	2.492481	2.492621	140
311	2.493458	2.493597	2.493737	2.493876	2.494015	139
312	2.494850	2.494989	2.495128	2.495267	2.495406	139
313	2.496237	2.496376	2.496514	2.496653	2.496791	139
314	2.497621	2.497759	2.497897	2.498035	2.498173	138

Num	0	1	2	3	4	Diff
315	2.498311	2.498448	2.498586	2.498724	2.498862	138
316	2.499687	2.499824	2 499962	2.500100	2.500236	137
317	2.501059	2.501196	2.501333	2.501470	2.501607	137
318	2.502427	2.502564	2.502700	2.502837	2.502973	136
319	2.503791	2.503927	2.504063	2.504199	2.504335	136
320	2.505150	2.505286	2.505421	2.505557	2.505693	136
321	2.506505	2.506640	2.506775	2.506911	2.507046	135
322	2.507856	2.507991	2.508125	2.508260	2.508395	135
323	2.509202	2.509337	2.509471	2.509606	2.509740	134
324	2.510545	2.510679	2.510813	2.510947	2.511081	134
325	2.511883	2.512017	2.512150	2.512284	2.512417	133
326	2.513218	2.513351	2.513484	2.513617	2.513750	133
327	2.514548	2.514680	2.514813	2.514946	2.515079	133
328	2.515874	2.516006	2.516139	2.516271	2.516403	132
329	2.517196	2.517328	2.517460	2.517592	2.517724	132
330	2.518514	2.518645	2.518777	2.518909	2.519040	132
331	2.519828	2.519959	2.520090	2.520221	2.520352	131
332	2.521138	2.521269	2.521400	2.521530	2.521661	131
333	2.522444	2.522575	2.522705	2.522835	2.522966	130
334	2.523746	2.523876	2.524006	2.524136	2.524266	130
335	2.525045	2.525174	2,525304	2.525433	2.525563	130
336	2.526339	2.526468	2.526598	2.526727	2.526856	129
337	2.527630	2.527759	2.527888	2.528016	2.528145	129
338	2.528917	2.529045	2.529174	2.529302	2.529430	128
339	2.530200	2.530328	2.530456	2.530584	2.530712	128
340	2.531479	2.531607	2.531734	2.531862	2.531989	128
341	2.532754	2.532882	2.533009	2.533136	2.533263	127
342	2.534026	2.534153	2.534280	2.534407	2.534534	127
343	2.535294	2.535421	2.535547	2.535674	2.535800	126
344	2.536558	2.536685	2.536811	2.536937	2.537063	126
345	2.537819	2.537945	2.538071	2.538197	2.538322	126
346	2.539076	2.539202	2.539327	2.539452	2.539578	125
347	2.540329	2.540455	2,540580	2,540705	2.540830	125
348	2.541579	2.541704	2.541829	2.541953	2.542078	125
349	2.542825	2.542950	2.543074	2.543199	2.543323	124
350	2.544068	2.544192	2.544316	2.544440	2.544564	124
351	2.545307	2.545431	2.545554	2.545678	2.545802	124
352	2.546543	2.546666	2.546789	2.546913	2.547036	123
353	2.547775	2.547898	2.548021	2,548144	2.548266	123
354	2.549003	2.549126	2 549249	2.549371	2.549494	123
355	2.550228	2.550351	2.550473	2.550595	2.550717	122
356	2.551450	2.551572	2.551694	2.551816	2.551938	122
357	2.552668	2.552790	2.552911	2.553033	2.553154	121

Num	5	6	7	8	9	Diff
315	2.498999	2.499137	2.499275	2.499412	2.499550	138
316	2.500374	2.500511	2.500648	2.500785	2.500922	137
317	2.501744	2.501880	2.502017	2.502154	2.502290	137
318	2,503109	2.503246	2.503382	2.503518	2.503654	136
319	2.504471	2.504607	2.504743	2.504878	2.505014	136
320	2.505828	2.505963	2.506099	2.506234	2 506370	136
321	2.507181	2.507316	2.507451	2.507586	2.507721	135
322	2.508530	2.508664	2.508799	2.508933	2.509068	135
323	2.509874	2.510008	2.510143	2.510277	2.510411	134
324	2.511215	2.511348	2.511482	2.511616	2.511750	134
325	2.512551	2.512684	2.512818	2.512951	2.513084	133
326	2.513883	2.514016	2.514149	2.514282	2.514415	133
327	2.515211	2.515344	2.515476	2.515609	2.515741	133
328	2.516535	2.516668	2.516800	2.516932	2.517064	132
329	2.517855	2.517987	2.518119	2.518251	2.518382	132
330	2.519171	2.519303	2.519434	2.519565	2.519697	132
331	2.520483	2.520614	2.520745	2.520876	2.521007	131
332	2.521792	2.521922	2.522053	2.522183	2.522314	131
333	2.523096	2.523226	2.523356	2.523486	2.523616	130
334	2.524396	2.524526	2 524656	2.524785	2.524915	130
335	2.525692	2.525822	2.525951	2.526081	2.526210	129
336	2.526985	2.527114	2.527243	2.527372	2.527501	129
337	2.528274	2.528402	2.528531	2.528660	2.528788	129
338	2.529559	2.529687	2.529815	2.529943	2.530072	128
339	2.530840	2.530968	2.531095	2.531223	2.531351	128
340	2.532117	2.532245	2.532372	2.532500	2.532627	128
341	2.533391	2.533518	2.533645	2.533772	2.533899	127
342	2.534661	2.534787	2.534914	2.535041	2.535167	127
343	2.535927	2.536053	2.536179	2.536306	2.536432	126
344	2.537189	2.537315	2.537441	2.537567	2.537693	126
345	2.538448	2.538574	2 538699	2.538825	2.538951	126
346	2.539703	2.539829	2.539954	2.540079	2.540204	125
347	2.540955	2.541080	2.541205	2.541330	2.541454	125
348	2.542203	2.542327	2.542452	2.542576	2.542701	125
349	2.543447	2.543571	2.543696	2.543820	2.543944	124
350	2.544688	2.544812	2,544936	2.545060	2.545183	124
351	2.545925	2.546049	2.546172	2.546296	2.546419	124
352	2.547159	2.547282	2.547405	2.547529	2.547652	123
353	2.548389	2,548512	2.548635	2.548758	2.548881	123
354	2.549616	2.549739	2.549861	2.549984	2.550106	123
355	2.550840	2.550962	2.551084	2.551206	2.551328	122
356	2.552059	2.552181	2.552303	2.552425	2.552546	122
357	2.553276	2.553397	2.553519	2.553640	2 553762	121

Num	0	1	2	3	4	*Diff*
358	2.553883	2.554004	2.554126	2.554247	2.554368	121
359	2.555094	2.555215	2.555336	2.555457	2.555578	121
360	2.556302	2.556423	2.556544	2.556664	2.556785	121
361	2.557507	2.557627	2.557748	2.557868	2.557988	120
362	2.558709	2.558828	2.558948	2.559068	2.559188	120
363	2.559907	2.560026	2.560146	2.560265	2.560385	120
364	2.561101	2.561221	2.561340	2.561459	2.561578	119
365	2.562293	2.562412	2.562531	2.562650	2.562768	119
366	2.563481	2.563600	2.563718	2.563837	2.563955	119
367	2.564666	2.564784	2.564903	2.565021	2.565139	118
368	2.565848	2.565966	2.566084	2.566202	2.566 20	118
369	2.567026	2.567144	2.567262	2.567379	2.567497	118
370	2.568202	2.568319	2.568436	2.568554	2.568671	117
371	2.569374	2.569491	2.569608	2.569725	2.569842	117
372	2.570543	2.570660	2.570776	2.570893	2.571010	117
373	2.571709	2.571825	2.571942	2.572058	2.572174	116
374	2.572872	2.572988	2.573104	2.573220	2.573336	116
375	2.574031	2,574147	2.574263	2.574379	2.574494	116
376	2.575188	2.575303	2.575419	2.575534	2.575650	115
377	2.576341	2.576456	2.576572	2.576687	2.576802	115
378	2.577492	2.577607	2.577721	2.577836	2.577951	115
379	2.578639	2.578754	2,578868	2.578983	2.579097	114
380	2.579784	2.579898	2.580012	2.580126	2.580240	14
381	2.580925	2.581039	2.581153	2.581267	2.581381	114
382	2.582063	2,582177	2.582291	2.582404	2.582518	114
383	2.583199	2.583312	2.583425	2.583539	2.583652	113
384	2.584331	2.584444	2.584557	2.584670	2.584783	113
385	2.585461	2.585573	2.585686	2.585799	2.585912	112
386	2.586587	2.586700	2.586812	2.586925	2.587037	112
387	2.587711	2.587823	2.587935	2.588047	2.588160	112
388	2.588832	2.588944	2.589055	2.589167	2.589279	112
389	2,589950	2.590061	2.590173	2.590284	2.590396	112
390	2.591065	2.591176	2.591287	2.591398	2.591510	111
391	2.592177	2.592288	2.592399	2.592510	2.592621	111
392	2.593286	2.593397	2.593508	2.593618	2.593729	111
393	2.594392	2.594503	2.594613	2.594724	2.594834	110
394	2,595496	2.595606	2.595717	2.595827	2.595937	110
395	2.596597	2.596707	2,596817	2.596927	2.597037	110
396	2.597695	2.597805	2.597914	2.598024	2.598134	110
397	2.598790	2.598900	2.599009	2.599119	2.599228	109
398	2.599883	2.599992	2.600101	2.600216	2.600319	109
399	2.600973	2.601082	2.601190	2.601299	2.601408	109
400	2.602060	2,602168	2,602277	2.602386	2.602494	108

Num	5	6	7	8	9	Diff
358	2.554489	2.554610	2.554731	2.554852	2.554973	121
359	2.555699	2.555820	2.555940	2.556061	2.556182	121
360	2.556905	2.557026	2.557146	2.557266	2.557387	120
361	2.558108	2.558228	2.558348	2.558469	2.558589	120
362	2.559308	2.559428	2.559548	2.559667	2.559787	120
363	2.560504	2.560624	2.560743	2.560863	2.560982	119
364	2.561697	2.561817	2.561936	2.562055	2.562174	119
365	2.562887	2.563006	2.563125	2.563244	2.563362	119
366	2.564074	2.564192	2.564311	2.564429	2.564548	119
367	2.565257	2.565375	2.565494	2.565612	2.565730	118
368	2.566437	2.566555	2.566673	2.566791	2.566909	118
369	2.567614	2.567732	2.567849	2.567967	2.568084	118
370	2.568788	2.568905	2.569023	2.569140	2.569257	117
371	2.569959	2.570076	2.570193	2.570309	2.570426	117
372	2.571126	2.571243	2.571359	2.571476	2.571592	117
373	2.572291	2.572407	2.572523	2.572639	2.572755	116
374	2.573452	2.573568	2.573684	2.573800	2.573915	116
375	2.574610	2.574726	2.574841	2.574957	2.575072	116
376	2.575765	2.575880	2.575996	2.576111	2.576226	115
377	2.576917	2.577032	2.577147	2.577262	2.577377	115
378	2.578066	2.578181	2.578295	2.578410	2.578525	115
379	2.579212	2.579326	2.579441	2.579555	2.579669	114
380	2.580355	2.580469	2.580583	2.580697	2.580811	114
381	2.581495	2.581608	2.581722	2.581836	2.581950	114
382	2.582631	2.582745	2.582858	2.582972	2.583085	114
383	2.583765	2.583879	2.583992	2.584105	2.584218	113
384	2.584896	2.585009	2.585122	2.585235	2.585348	113
385	2.586024	2.586137	2.586250	2.586362	2.586475	113
386	2.587149	2.587262	2.587374	2.587486	2.587599	112
387	2.588272	2.588384	2.588496	2.588608	2.588720	112
388	2.589391	2.589503	2.589614	2.589726	2.589838	112
389	2.590507	2.590619	2.590730	2.590842	2.590953	112
390	2.591621	2.591732	2.591843	2.591955	2.592066	111
391	2.592732	2.592843	2.592954	2.593064	2.593175	111
392	2.593840	2.593950	2.594061	2.594171	2.594282	111
393	2.594945	2.595055	2.595165	2.595276	2.595386	110
394	2.596047	2.596157	2.596267	2.596377	2.596487	110
395	2.597146	2.597256	2.597366	2.597476	2.597585	110
396	2.598243	2.598353	2.598462	2.598572	2.598681	110
397	2.599337	2.599446	2.599556	2.599665	2.599774	109
398	2.600428	2.600537	2.600646	2.600755	2.600864	109
399	2.601517	2.601625	2.601734	2.601843	2.601951	109
400	2.602602	2.602711	2.602819	2.602928	2.603036	108

Num	0	1	2	3	4	*Diff*
401	2.603144	2.603253	2.603361	2.603469	2.603577	108
402	2.604226	2.604334	2.604442	2.604550	2.604658	108
403	2.605305	2.605413	2.605520	2.605628	2.605736	108
404	2.606381	2.606489	2.606596	2.606704	2.606811	107
405	2.607455	2.607562	2.607669	2.607777	2,607884	107
406	2.608526	2.608633	2.608740	2.608847	2,608954	107
407	2.609594	2.609701	2.609808	2.609914	2,610021	107
408	2.610660	2.610767	2.610873	2.610979	2.611086	106
409	2.611723	2.611829	2.611936	2.612042	2.612148	106
410	2.612784	2.612890	2.612996	2.613102	2.613208	106
411	2.613842	2.613947	2.614053	2.614159	2.614264	106
412	2.614897	2.615003	2.615108	2.615213	2.615319	105
413	2,615950	2.616055	2.616160	2.616265	2.616370	105
414	2,617000	2.617105	2.617210	2.617315	2.617420	105
415	2.618048	2.618153	2.618257	2.618362	2.618466	105
416	2.619093	2.619198	2.619302	2.619406	2.619511	104
417	2,620136	2.620240	2.620344	2.620448	2.620552	104
418	2.621176	2,621280	2.621384	2.621488	2.621592	104
419	2.622214	2.622318	2.622421	2.622525	2.622628	104
420	2.623249	2.623353	2.623456	2.623559	2.623663	103
421	2.624282	2.624385	2.624488	2.624591	2.624694	103
422	2.625312	2.625415	2,625518	2.625621	2.625724	103
423	2.626340	2.626443	2.626546	2.626648	2,626751	103
424	2,627366	2.627468	2.627571	2.627673	2.627775	102
425	2,628389	2,628491	2.628593	2.628695	2.628797	102
426	2.629410	2.629511	2.629613	2.629715	2.629817	102
427	2.630428	2.630529	2.630631	2.630733	2.630834	102
428	2.631444	2.631545	2.631647	2.631748	2.631849	101
429	2.632457	2.632558	2.632660	2.632761	2.632862	101
430	2.633468	2.633569	2.633670	2.633771	2.633872	101
431	2.634477	2.634578	2.634679	2.634779	2.634880	100
432	2,635484	2.635584	2.635685	2.635785	2.635886	100
433	2.636488	2.636588	2.636688	2.636789	2.636889	100
434	2.637490	2.637590	2.637690	2.637790	2.637890	100
435	2.638489	2.638589	2.638689	2.638789	2.638888	99
436	2,639486	2.639586	2.639685	2.639785	2.639885	99
437	2.640481	2.640581	2.640680	2.640779	2.640879	99
438	2.641474	2.641573	2,641672	2.641771	2.641870	99
449	2.642464	2.642563	2.642662	2.642761	2.642860	99
440	2.643453	2.643551	2.643650	2.643749	2.643847	98
441	2.644439	2.644537	2.644635	2.644734	2.644832	98
442	2.645422	2.645520	2.645619	2.645717	2.645815	98
443	2.646404	2,646502	2,646600	2.646698	2.646796	98

Num	5	6	7	8	9	Diff
401	2.603685	2.603794	2.603902	2.604010	2.604118	108
402	2.604766	2.604874	2.604982	2.605089	2.605197	108
403	2.605843	2.605951	2.606059	2.606166	2.606274	108
404	2.606918	2.607026	2.607133	2.607240	2.607348	107
405	2.607991	2.608098	2.608205	2.608312	2.608419	107
406	2.609060	2.609167	2.609274	2.609381	2.609488	107
407	2.610128	2.610234	2.610341	2.610447	2.610554	107
408	2.611192	2.611298	2.611405	2.611511	2.611617	106
409	2.612254	2.612360	2.612466	2.612572	2.612678	106
410	2.613313	2.613419	2.613525	2.613630	2.613736	106
411	2.614370	2.614475	2.614581	2.614686	2.614792	106
412	2.615424	2.615529	2.615634	2.615740	2.615845	105
413	2.616475	2.616580	2.616685	2.616790	2.616895	105
414	2.617524	2.617629	2.617734	2.617839	2.617943	105
415	2.618571	2.618675	2.618780	2.618884	2.618989	105
416	2.619615	2.619719	2.619823	2.619928	2.620032	104
417	2.620656	2.620760	2.620864	2.620968	2.621072	104
418	2.621695	2.621799	2.621903	2.622007	2.622110	104
419	2.622732	2.622835	2.622939	2.623042	2.623146	104
420	2.623766	2.623869	2.623972	2.624076	2.624179	103
421	2.624798	2.624901	2.625004	2.625107	2.625209	103
422	2.625892	2.625929	2.626032	2.626135	2.626238	103
423	2.626853	2.626956	2.627058	2.627161	2.627263	103
424	2.627878	2.627980	2.628082	2.628184	2.628287	102
425	2.628900	2.629002	2.629104	2.629206	2.629308	102
426	2.629919	2.630021	2.630123	2.630224	2.630326	102
427	2.630936	2.631038	2.631139	2.631241	2.631342	102
428	2.631951	2.632052	2.632153	2.632255	2.632356	101
429	2.632963	2.633064	2.633165	2.633266	2.633367	101
430	2.633973	2.634074	2.634175	2.634276	2.634376	100
431	2.634981	2.635081	2.635182	2.635283	2.635383	100
432	2.635986	2.636086	2.636187	2 636287	2.636388	100
433	2.636989	2.637089	2.637189	2.637289	2.637390	100
434	2.637990	2.638090	2.638190	2.638289	2.638389	99
435	2.638988	2.639088	2.639188	2.649287	2.639387	99
436	2.639984	2.640084	2.640183	2.640283	2.640382	99
437	2 640978	2.641077	2.641176	2.641276	2.641375	99
438	2.641970	2.642069	2 642168	2.642267	2.642366	99
439	2.642959	2.643058	2.643156	2.643255	2.643354	99
440	2.643946	2.644044	2.644143	2.644242	2.644340	98
441	2.644931	2.645029	2.645127	2.645226	2.645324	98
442	2.645913	2.646011	2.646109	2.646208	2.646306	98
443	2.645894	2.646991	2.647089	2.647187	2 647285	98

A Table of Logarithms.

Num.	0	1	2	3	4	Diff
444	2.647383	2.647481	2.647578	2.647676	2.647774	98
445	2.648360	2.648458	2.648555	2.648653	2.648750	97
446	2.649335	2.649432	2.649530	2.649627	2.649724	97
447	2.650307	2.650405	2.650502	2.650599	2.650696	97
448	2.651278	2.651375	2.651472	2.651569	2.651666	97
449	2.652246	2.652343	2.652440	2.652536	2.652633	97
450	2.653212	2.653309	2.653405	2.653502	2.653598	96
451	2.654176	2.654273	2.654369	2.654465	2.654562	96
452	2.655138	2.655234	2.655331	2.655427	2.655523	96
453	2.656098	2.656194	2.656290	2.656386	2.656481	96
454	2.657056	2.657151	2.657247	2.657343	2.657438	96
455	2.658011	2.658107	2.658202	2.658298	2.658393	95
456	2.658965	2.659060	2.659155	2.659250	2.659346	95
457	2.659916	2.660011	2.660106	2.660201	2.660296	95
458	2.660865	2.660960	2.661055	2.661150	2.661245	95
459	2.661813	2.661907	2.662002	2.662096	2.661191	95
460	2.662758	2.662852	2.662947	2.663041	2.663135	94
461	2.663701	2.663795	2.663889	2.663983	2.664078	94
462	2.664642	2.664736	2.664830	2.664924	2.665018	94
463	2.665581	2.665675	2.665768	2.665862	2.665956	94
464	2.666518	2.666612	2.666705	2.666799	2.666892	94
465	2.667453	2.667546	2.667640	2.667733	2.667826	93
466	2.668386	2.668479	2.668572	2.668665	2.668758	93
467	2.669317	2.669410	2.669503	2.669596	2.669689	93
468	2.670246	2.670339	2.670431	2.670524	2.670617	93
469	2.671173	2.671265	2.671358	2.671451	2.671543	93
470	2.672098	2.672190	2.672283	2.672375	2.672467	92
471	2.673021	2.673113	2.673205	2.673297	2.673390	92
472	2.673942	2.674034	2.674126	2.674218	2.674310	92
473	2.674861	2.674953	2.675045	2.675136	2.675228	92
474	2.675778	2.675870	2.675961	2.676053	2.676145	92
475	2.676694	2.676785	2.676870	2.676968	2.677059	91
476	2.677607	2.677698	2.677789	2.677881	2.677972	91
477	2.678518	2.678609	2.678700	2.678791	2.678882	91
478	2.679428	2.679519	2.679610	2.679700	2.679791	91
479	2.680335	2.680426	2.680517	2.680607	2.680698	91
480	2.681241	2.681332	2.681422	2.681513	2.681603	90
481	2.682145	2.682235	2 682326	2.682416	2.682506	90
482	2.683047	2.683137	2.683227	2,683317	2.683407	90
483	2.683947	2.684037	2.684127	2.684217	2.684307	90
484	2.684845	2.684935	2.685025	2.685114	2.685204	90
485	2.685742	2.685831	2.685921	2.686010	2.686100	89
486	2.686636	2.686726	2.686815	2.686904	2.686994	89

Num	5	6	7	8	9	Diff
444	2.647872	2.647969	2.648067	2.648165	2.648262	98
445	2.648848	2.648945	2.649043	2.649140	2.649237	97
446	2.649821	2.649919	2.650016	2.650113	2.650210	97
447	2.650793	2.650890	2.650987	2.651084	2.651181	97
448	2.651762	2.651859	2.651956	2.652053	2.652150	97
449	2.652730	2.652826	2.652923	2.653019	2.653116	97
450	2.653695	2.653791	2.653888	2.653984	2.654080	96
451	2.654658	2.654754	2.654850	2.654946	2.655042	96
452	2.655619	2.655714	2.655810	2.655906	2.656002	96
453	2.656577	2.656673	2.656769	2.656864	2.656960	96
454	2.657534	2.657629	2.657725	2.657820	2.657916	96
455	2.658488	2.658584	2.658679	2.658774	2.658870	95
456	2.659441	2.659536	2.659631	2.659726	2.659821	95
457	2.660391	2.660486	2.660581	2.660676	2.660771	95
458	2.661339	2.661434	2.661529	2.661623	2.661718	95
459	2.662285	2.662380	2.662474	2.662569	2.662663	95
460	2.663230	2.663324	2.663418	2.663512	2.663607	94
461	2.664172	2.664266	2.664360	2.664454	2.664548	94
462	2.665112	2.665206	2.665299	2.665393	2.665487	94
463	2.666050	2.666143	2.666237	2.666331	2.666424	94
464	2.666986	2.667079	2.667173	2.667266	2.667359	94
465	2.667920	2.668013	2.668106	2.668199	2.668293	93
466	2.668852	2.668945	2.669038	2.669131	2.669224	93
467	2.669782	2.669874	2.669967	2.670060	2.670153	93
468	2.670710	2.670802	2.670895	2.670988	2.671080	93
469	2.671636	2.671728	2.671821	2.671913	2.672005	93
470	2.672560	2.672652	2.672744	2.672836	2.672929	92
471	2.673482	2.673574	2.673666	2.673758	2.673850	92
472	2.674402	2.674494	2.674586	2.674677	2.674769	92
473	2.675320	2.675412	2.675503	2.675595	2.675687	92
474	2.676236	2.676328	2.676419	2.676511	2.676602	92
475	2.677150	2.677242	2.677333	2.677424	2.677516	91
476	2.678063	2.678154	2.678245	2.678336	2.678427	91
477	2.678973	2.679064	2.679155	2.679246	2.679337	91
478	2.679882	2.679973	2.680063	2.680154	2.680245	91
479	2.680789	2.680879	2.680970	2.681060	2.681151	91
480	2.681693	2.681784	2.681874	2.681964	2.682055	90
481	2.682596	2.682686	2.682777	2.682867	2.682957	90
482	2.683497	2.683587	2.683677	2.683867	2.683857	90
483	2.684396	2.684486	2.684576	2.684666	2.684756	90
484	2.685294	2.685383	2.685473	2.685563	2.685652	90
485	2.686189	2.686279	2.686368	2.686457	2.686547	89
486	2.687083	2.687172	2.687261	2.687351	2.687440	89

Num.	0	1	2	3	4	*Diff*
487	2.687529	2.687618	2.687707	2.687796	2.687885	89
488	2.688420	2.688509	2.688598	2.688687	2.688776	89
489	2.689309	2.689398	2.689486	2.689575	2.689664	89
490	2.690196	2.690285	2.690373	2.690462	2.690550	89
491	2.691081	2.691170	2.691258	2.691347	2.691435	88
492	2.691965	2.692053	2.692142	2.692230	2.692318	88
493	2.692847	2.692935	2.693023	2.693111	2.693199	88
494	2.693727	2.693815	2.693903	2.693991	2.694078	88
495	2.694605	2.694693	2.694781	2.694868	2.694956	88
496	2.695482	2.695569	2.695657	2.695744	2.695832	87
497	2.696356	2.696444	2.696531	2.696618	2.696706	87
498	2.697229	2.697316	2.697404	2.697491	2.697578	87
499	2.698100	2.698188	2.698275	2.698362	2.698448	87
500	2.698970	2.699057	2.699144	2.699230	2.699317	87
501	2.699838	2.699924	2.700011	2.700098	2.700184	87
502	2.700704	2.700790	2.700877	2.700963	2.701050	86
503	2.701568	2.701654	2.701741	2.701827	2.701913	86
504	2.702430	2.702517	2.702603	2.702689	2.702775	86
505	2.703291	2.703377	2.703463	2.703549	2.703635	86
506	2.704150	2.704236	2.704322	2.704408	2.704494	86
507	2.705008	2.705094	2.705179	2.705265	2.705350	86
508	2.705864	2.705949	2.706035	2.706120	2.706205	85
509	2.706718	2.706803	2.706888	2.706974	2.707059	85
510	2.707570	2.707655	2.707740	2.707826	2.707911	85
511	2.708421	2.708506	2.708591	2.708676	2.708761	85
512	2.709270	2.709355	2.709440	2.709524	2.709609	85
513	2.710117	2.710202	2.710287	2.710371	2.710456	85
514	2.710963	2.711048	2.711132	2.711216	2.711301	84
515	2.711807	2.711891	2.711076	2.712060	2.712144	84
516	2.712650	2.712734	2.712818	2.712902	2.712986	84
517	2.713490	2.713574	2.713658	2.713742	2.713826	84
518	2.714330	2.714414	2.714497	2.714581	2.714665	84
519	2.715167	2.715251	2.715335	2.715418	2.715502	84
520	2.716003	2.716087	2.716170	2.716254	2.716337	83
521	2.716838	2.716921	2.717004	2.717088	2.717171	83
522	2.717670	2.717754	2.717837	2.717920	2.718003	83
523	2.718502	2.718585	2.718668	2.718751	2.718834	83
524	2.719331	2.719414	2.719497	2.719580	2.719663	83
525	2.720159	2.720242	2.720325	2,720407	2.720490	83
526	2.720986	2.721068	2 721151	2.721233	2.721316	82
527	2.721811	2.721893	2.72197[illegible]	2.722058	2.722140	82
528	2.722634	2.722716	2.722798	2.722881	2.722963	82
529	2.723456	2.723538	2.723620	2.723702	2.723784	82

Numb	5	6	7	8	9	*Diff*
487	2.687975	2.688064	2.688153	2.688242	2.688331	89
488	2.688865	2.688953	2.689042	2.689131	2.689210	89
489	2.689753	2.689841	2.689930	2.690019	2.690107	89
490	2.690639	2.690727	2.690816	2.690905	2.690993	89
491	2.691523	2.691612	2.691700	2.691788	2.691877	88
492	2.692406	2.692494	2.692583	2.692671	2.692759	88
493	2.693287	2.693375	2.693463	2.693551	2.693639	88
494	2.694166	2.694254	2.694342	2.694430	2.694517	88
495	2.695044	2.695131	2.695219	2.695306	2.695394	88
496	2.695919	2.696007	2.696094	2.696182	2.696269	87
597	2.696793	2.696880	2.696968	2.697055	2.697142	87
598	2.697665	2.697752	2.697839	2.697926	2.698013	87
599	2.698535	2.698622	2.698709	2.698796	2.698883	87
500	2.609404	2.699491	2.699578	2,699664	2.699751	87
501	2.700271	2.700357	2.700444	2.700531	2.700617	87
502	2.701136	2.701222	2.701309	2.701395	2.701482	86
503	2,701999	2.702086	2.702172	2.702258	2.702344	86
504	2.702861	2.702947	2.703033	2.703119	2,703205	86
505	2.703721	2.703807	2.703893	2.703979	2.704065	86
506	2.704579	2.704665	2.704751	2.704837	2.704922	86
507	2.705436	2.705522	2.705607	2.705693	2.705778	86
508	2.706291	2.706376	2.706462	2.706547	2.706632	85
509	2.707144	2.707229	2.707315	2.707400	2.707485	85
510	2.707996	2.708081	2 708166	2.708251	2.708336	85
511	2.708846	2.708931	2.709015	2.709100	2.709185	85
512	2.709694	2.709779	2.709863	2.709948	2.710033	85
513	2.710540	2.710695	2.710710	2.710794	2.710879	85
514	2,711385	2.711470	2.711554	2.711638	2,711723	84
515	2.712229	2.712313	2.712397	2.712481	2.712565	84
516	2.713070	2.713154	2.713238	2.713322	2.713406	84
517	2.713910	2.713994	2.714078	2.714162	2,714246	84
518	2.714749	2.714832	2.714916	2.715000	2.715084	84
519	2.715586	2.715669	2.715753	2.715836	2.715920	84
520	2.716421	2.716504	2.716588	2.716671	2.716754	83
521	2.717254	2.717338	2.717421	2.717504	2.717587	83
522	2.718086	2.718169	2.718253	2.718336	2.718419	83
523	2.718917	2.719000	2.719083	2.719165	2.719248	83
524	2.719745	2.719828	2.719911	2.719994	2.720077	83
525	2.720573	2.720655	2.720738	2.720821	2.720903	83
526	2.721398	2.721481	2.721563	2.721646	2.721728	82
527	2.722222	2.722305	2.722387	2.722469	2.722552	82
528	2.723045	2.723127	2.723209	2.723291	2.723374	82
529	2.723866	2,723948	2 724030	2.724112	2.724194	82

A Table of Logarithms

Numb	0	1	2	3	4	*Diff*
530	2.724276	2.724358	2.724440	2.724522	2.724603	82
531	2.725094	2.725176	2.725258	2.725340	2.725421	82
532	2.725912	2.726993	2.726075	2.726156	2.726238	82
533	2.726727	2.726809	2.726890	2.726972	2.727053	81
534	2.727541	2.727623	2.727704	2.727785	2.727866	81
535	2.728354	2.728435	2.728516	2.728597	2.728678	81
536	2.729165	2.729246	2.729327	2.729408	2.729486	81
537	2.729974	2.730055	2.730136	2.730217	2.730298	81
538	2.730782	2.730863	2.730944	2.731024	2.731105	81
539	2.731589	2.731669	2.731750	2.731830	2.731911	81
540	2.732394	2.732474	2.732555	2.732635	2.732715	80
541	2.733197	2.733277	2.733358	2.733438	2.733518	80
542	2.734999	2.733079	2.734159	2.734240	2.734320	80
543	2.734800	2.734880	2.734660	2,735040	2.735120	80
544	2.735599	2.735679	2.735758	2.735838	2.735918	80
545	2.736396	2.736476	2.736556	2.736635	2.736715	80
546	2.737193	2.737272	2.737352	2.737431	2.737511	79
547	2.737987	2.738067	2.738146	2.738225	2,738305	79
548	2.738781	2.738860	2.738939	2.739018	2.739097	79
549	2.739572	2.739651	2.739730	2.739810	2.739889	79
550	2.740363	2.740442	2.740521	2.740599	2.740678	79
551	2.741153	2.741230	2.741309	2.741388	2.741467	79
552	2.741939	2.742018	2.742096	2.742175	2.742254	79
553	2.742725	2.742804	2 742882	2.742961	2.743039	78
554	2.743510	2.743588	2.743666	2.743745	2.743823	78
555	2.744293	2.744371	2.744449	2.744528	2.744606	78
556	2.745075	2.745153	2.745231	2.745309	2.745387	78
557	2.745855	2.745933	2.746011	2.746089	2,746167	78
558	2.746634	2.746712	2.746790	2.746868	2.746945	78
559	2.747412	2.747489	2.747567	2.747645	2.747722	78
560	2.748188	2.749266	2.748343	2.748421	2,748498	77
561	2.748963	2.749040	2.749118	2.749195	2.749272	77
562	2.749736	2.749814	2.759891	2.749968	2.750045	77
563	2.750508	2.750586	2.750663	2.750740	2.750817	77
564	2.751279	2.751356	2.751433	2.751510	2.751587	77
565	2.752048	2.752125	2.752202	2.752279	2.752356	77
566	2.752816	2.752893	2.752970	2.753047	2.753123	77
567	2.753583	2.753660	2.753736	2.753813	2.753889	77
568	2.754348	2.754425	2.754501	2.754578	2.754654	77
569	2.755112	2.755189	2.755265	2.755341	2.755417	76
570	2.755875	2.755951	2.756027	2.756103	2.756180	76
571	2.756636	2.756712	2.756788	2.756864	2.756940	76
572	2.757396	2,757472	2 757548	2.757624	2.757700	76

Num	5	6	7	8	9	*Diff*
530	2.724685	2.724767	2.724849	2.724931	2.725013	82
531	2.725503	2.725585	2.725667	2.725748	2.725830	82
532	2.726320	2.726401	2.726483	2.726564	2.726646	82
533	2.727134	2.727216	2.727297	2.727379	2.727460	81
534	2.727948	2.728029	2.728110	2.728191	2.728273	81
535	2.728759	2.728841	2.728922	2.729003	2.729084	81
536	2.729570	2.729651	2.729732	2.729813	2.729893	81
537	2.730378	2.730459	2.730540	2.730621	2.730702	81
538	2.731186	2.731266	2.731347	2.731428	2.731508	81
539	2.731991	2.732072	2.732152	2.732233	2.732313	81
540	2.732796	2.732876	2.732956	2.732087	2.733117	80
541	2.733598	2.733679	2.733759	2.733839	2.733919	80
542	2.734400	2.734480	2.734560	2.734640	2.734720	80
543	2.735200	2.735279	2.735359	2,735439	2.735519	80
544	2.735998	2.736078	2.736157	2.736237	2.736317	80
545	2.736795	2.736874	2.736954	2.737034	2.737113	80
546	2.737590	2.737670	2.737749	2.737829	2.737908	79
547	2.738384	2.738463	2.738543	2.738622	2,738701	79
548	2.739177	2.739256	2.739335	2.739414	2.739493	79
549	2.739968	2.740047	2.740126	2.740205	2.740284	79
550	2.740757	2.740836	2.740915	2.740994	2.741073	79
551	2.741546	2.741624	2.741703	2.741782	2.741860	79
552	2.742333	2.742411	2.742489	2.742568	2.742647	79
553	2.743118	2.743196	2.743275	2.743353	2.743431	78
554	2.743902	2.743980	2.744058	2.744136	2.744214	78
555	2.744684	2.744762	2.744840	2.744919	2.744997	78
556	2.745465	2.745543	2.745621	2.745699	2.745777	78
557	2.746245	2.746323	2.746401	2.746479	2,746556	78
558	2.747023	2.747101	2.747179	2.747256	2.747334	78
559	2.747800	2.747878	2.747955	2.748033	2.748110	78
560	2.748576	2.748653	2.748731	2.748808	2,748885	77
561	2.749350	2.749427	2.749504	2.749582	2.749659	77
562	2.750123	2.750200	2.750277	2.750354	2.750431	77
563	2.750894	2.750971	2.751048	2.751125	2.751202	77
564	2.751664	2.751741	2.751818	2.751895	2.751972	77
565	2.752433	2.752509	2.752586	2.752663	2.752740	77
566	2.753200	2.753277	2.753353	2.753430	2.753506	77
567	2.753966	2.754042	2.754119	2.754195	2.754272	77
568	2,754730	2.754807	2.754883	2.754960	2.755036	77
569	2.755494	2.755570	2.755646	2.755722	2.755799	76
570	2.756256	2.756332	2.756408	2.756484	2.756560	76
571	2.757016	2.757092	2.757168	2.757244	2.757320	76
572	2.757775	2,757851	2.757927	2.758003	2.758079	76

Num	0	1	2	3	4	Diff
573	2.758155	2.758230	2.758306	2-758382	2.758458	76
574	2.758912	2.758988	2.759063	2.759139	2.759214	76
575	2.759668	2.759743	2.759819	2.759894	2.759970	75
576	2.760422	2.760498	2.760573	2.760649	2.760724	75
577	2.761176	2.761251	2.761326	2.761402	2.761477	75
578	2.961928	2.762003	2.762078	2.762153	2.762228	75
579	2.762679	2.762754	2.762829	2.762904	2.762978	75
580	2.763428	2.763503	2.763578	2.763652	2.763727	75
581	2.764176	2.764251	2.764326	2.764400	2.764475	75
582	2.764923	2.764998	2.765072	2.765147	2.765221	75
583	2.765669	2.765743	2.765818	2.765892	2.765966	74
584	2.766413	2.766487	2.766562	2.766636	2.766710	74
585	2.767156	2.767230	2.767304	2.767379	2.767453	74
586	2.767898	2.767972	2.768046	2.768120	2.768194	74
587	2.768638	2.768712	2.768786	2.768860	2.768934	74
588	2.769377	2,769451	2.769525	2.769599	2.769673	74
589	2.770115	2.770189	2.770263	2.770336	2.770410	74
590	2.770852	2.770926	2.770999	2.771073	2.771146	74
591	2.771587	2.771661	2.771734	2.771808	2.771881	73
592	2.772322	2.772395	2.772468	2.772542	2.772615	73
593	2.773055	2.773128	2.773201	2.773274	2.773348	73
594	2.773786	2.773860	2,773933	2.774006	2.774079	73
595	2.774517	2.774590	2.774663	2.774736	2.774809	73
596	2,775246	2.775319	2.775392	2.775465	2.775538	73
597	2.775974	2,776047	2.776120	2.776193	2.776265	73
598	2.776701	2.776774	2.776846	2.776919	2.716992	73
599	2,777427	2.777499	2.777572	2.777644	2.777717	72
600	2.778151	2.778224	2.778296	2.778368	2.778441	72
601	2.778874	2.778947	2.779019	2.779091	2.779163	72
602	2.779596	2.779669	2.779741	2.779813	2.779885	72
603	2.780317	2.780389	2.780461	2.780533	2.780605	72
604	2.781037	2.781109	2.781181	2.781253	2.781324	72
605	2.781755	2.781827	2.781899	2.781971	2.782042	72
606	2.782473	2.782544	2.782616	2.782688	2.782759	72
607	2.783189	2.783260	2.783332	2.783403	2.783475	71
608	2.783904	2.783975	2.784046	2.784118	2.784189	71
609	2.784617	2.784689	2.784760	2.784831	2.784902	71
610	2.785330	2.785401	2.785472	2.785543	2.785615	71
611	2.786041	2.786112	2.786183	2.786254	2.786325	71
612	2.786751	2.786822	2.786893	2.786964	2.787035	71
613	2.787460	2.787531	2.787602	2.787673	2.787744	71
614	2.788168	2.788239	2,788310	2.788381	2.788451	71
615	2.788875	2.788946	2.789016	2.789087	2.789158	71

Num.	5	6	7	8	9	*Diff*
573	2.758533	2.758609	2.758685	2.758761	2.758836	76
574	2.759290	2.759366	2.759441	2.759517	2.759592	76
575	2.760045	2.760121	2.760196	2.760272	2.760347	75
576	2.760799	2.760875	2.760950	2.761025	2.761101	75
577	2.761552	2.761627	2.761702	2.761778	2.761853	75
578	2.762303	2.762378	2.762453	2.762529	2.762604	75
579	2.763053	2.763128	2.763203	2.763278	2.763353	75
580	2.763802	2.763877	2.763952	2.764027	2.764101	75
581	2.764550	2.764624	2.764699	2.764774	2.764848	75
582	2.765296	2.765370	2.765445	2.765520	2.765594	75
583	2.766041	2.766115	2.766190	2.766264	2.766338	74
584	2.766785	2.766859	2.766933	2.767007	2.767082	74
585	2.767527	2.767601	2.767675	2.767749	2.767823	74
586	2.768268	2.768342	2.768416	2.768490	2.768564	74
587	2.769008	2.769082	2.769156	2.769230	2.769303	74
588	2.769746	2.769820	2.769894	2.769968	2.770042	74
589	2.770484	2.770557	2.770631	2.770705	2.770778	74
590	2.771220	2.771293	2.771367	2.771440	2.771514	74
591	2.771955	2.772028	2.772102	2.772175	2.772248	73
592	2.772688	2.772762	2.772835	2.772908	2.772981	73
593	2.773421	2.773494	2.773567	2.773640	2.773713	73
594	2.774152	2.774225	2.774298	2.774371	2.774444	73
595	2.774882	2.774955	2.775028	2.775101	2.775173	73
596	2.775610	2.775683	2.775756	2.775829	2.775902	73
597	2.776338	2.776411	2.776483	2.776556	2.776629	73
598	2.777064	2.777137	2.777209	2.777282	2.777354	73
599	2.777789	2.777862	2.777934	2.778006	2.778079	73
600	2.778513	2.778585	2.778658	2.778730	2.778802	73
601	2.779236	2.779308	2.779380	2.779452	2.779524	72
602	2.779957	2.780029	2.780101	2.780173	2.780245	72
603	2.780677	2.780749	2.780821	2.780893	2.780965	72
604	2.781396	2.781468	2.781540	2.781612	2.781684	72
605	2.782114	2.782186	2.782258	2.782329	2.782401	72
606	2.782831	2.782902	2.782974	2.783046	2.783117	71
607	2.783546	2.783618	2.783689	2.783761	2.783832	71
608	2.784261	2.784332	2.784403	2.784475	2.784546	71
609	2.784974	2.785045	2.785116	2.785187	2.785259	71
610	2.785686	2.785757	2.785828	2.785899	2.785970	71
611	2.786396	2.786467	2.786538	2.786609	2.786680	71
612	2.787106	2.787177	2.787248	2.787319	2.787390	71
613	2.787815	2.787885	2.787956	2.788027	2.788098	71
614	2.788522	2.78859	2.788663	2.788734	2.788804	71
615	2.789228	2.789299	2.789369	2,789440	2.789510	71

Num	0	1	2	3	4	*Diff*
616	2.789581	2.789651	2.789722	2-789792	2.789863	70
617	2.790285	2.790356	2.790426	2.790496	2.790567	70
618	2.790989	2.791059	2.791129	2.791199	2.791269	70
619	2.791691	2.791761	2.791831	2 791901	2.791971	70
620	2.792392	2.792462	2.792532	2.792602	2.792672	70
621	2.793092	2.793162	2.793231	2.793301	2.793371	70
622	2.793790	2.793860	2.793930	2.794000	2.794070	70
623	2.794488	2.794558	2.794627	2.794697	2.794767	70
624	2.795185	2.795254	2.795324	2.795393	2.795463	70
625	2.795880	2.795949	2.796019	2.796088	2.796158	69
626	2.796574	2.796644	2.796713	2.796782	2.796852	69
627	2.797268	2.797337	2.797406	2 797475	2.797545	69
628	2.797960	2 798029	2.798098	2.798167	2.798237	69
629	2.798651	2.798720	2.798789	2.798858	2.798927	69
630	2.799341	2.799409	2.799478	2.799547	2.799616	69
631	2.800029	2.800098	2.800166	2.800236	2.800305	69
632	2.800717	2.800786	2.800854	2.800923	2.800992	69
633	2.801404	2,801472	2.801541	2.801609	2.801678	69
634	2.802089	2.802158	2.802226	2.802295	2.802363	68
635	2.802774	2.802842	2.802910	2.802979	2.803047	68
636	2.803457	2.803525	2.803594	2.803662	2.803730	68
637	2.804139	2.804208	2,804276	2.804344	2.804412	68
638	2.804821	2.804889	2.804957	2.805025	2.805093	68
639	2,805501	2.805569	2.805637	2.805705	2.805773	68
640	2.806180	2,806248	2.806316	2.806384	2.806451	68
641	2.806858	2.806926	2.806994	2.807061	2.807129	68
642	2 807535	2.807603	2 807670	2.807738	2.807806	68
643	2.808211	2.808279	2.808346	2.808414	2.808481	67
644	2.808886	2.808953	2.809021	2.809088	2.809155	67
645	2,809560	2.809627	2.809694	2.809762	2.809829	67
646	2.810233	2.800300	2.810367	2.810434	2.810501	67
647	2.810904	2.810971	2.811038	2.811106	2.811173	67
648	2.811575	2.811642	2.811709	2.811776	2.811843	67
649	2.812245	2.812312	2.812378	2.812445	2.812512	67
650	2.812913	2.812980	2.813047	2.813114	2.813180	67
651	2.813581	2.813648	2 813714	2.813781	2.813848	67
652	2,814248	2.814314	2.814381	2.814447	2.814514	67
653	2.814913	2.814980	2,815046	2.815113	2.815179	66
654	2.815578	2.815644	2.815710	2.215777	2.815843	65
655	2.816241	2.816308	2.816374	2.816440	2.816506	66
656	2.816904	2.816970	2.817036	2.817102	2.817169	66
657	2.817565	2.817631	2.817698	2.817764	2.817830	66
658	2.818226	2.818292	2.818358	2.818424	2.818490	66

Numb	5	6	7	8	9	*Diff.*
616	2.799933	2.790003	2.790074	2.790144	2.790215	70
617	2.790637	2.790707	2.790778	2.790848	2.790918	70
618	2.791340	2.791410	2.791480	2.791550	2.791620	70
619	2.792041	2.792111	2.792181	2.792252	2.792322	70
620	2.792742	2.792812	2.792882	2.792952	2.793022	70
621	2.793441	2.793511	2.793581	2.793651	2.793721	70
622	2.794139	2.794209	2.794279	2.794349	2.794418	70
623	2.794836	2.794906	2.794976	2.795045	2.795115	70
624	2.795532	2.795602	2.795671	2.795741	2.795810	70
625	2.796227	2.796297	2.796366	2.796436	2.796505	69
626	2.796921	2.796990	2.797060	2.797129	2.797198	69
627	2.797614	2.797683	2.797752	2.797821	2.797890	69
628	2.798305	2.798374	2.798443	2.798512	2.798582	69
629	2.798996	2.799065	2.799134	2.799203	2.799272	69
630	2.799685	2.799754	2.799823	2.799892	2.799960	69
631	2.800373	2.800442	2.800511	2.800580	2.800648	69
632	2.801060	2.801129	2.801198	2.801267	2.801335	69
633	2.801747	2.801815	2.801884	2.801952	2.802021	69
634	2.802432	2.802500	2.802568	2.802637	2.802705	68
635	2.803116	2.803184	2.803252	2.803321	2.803389	68
636	2.803798	2.803867	2,803935	2.804003	2,804071	68
637	2.804480	2.804548	2.804616	2.804685	2.804753	68
638	2.805161	2.805229	2.805297	2.805365	2,805433	68
639	2.805840	2.805908	2.805976	2.806044	2.806112	68
640	2.806519	2.806587	2.806655	2,806723	2.806790	68
641	2.807196	2.807264	2.807332	2,807400	2.807467	68
642	2.807873	2.807941	2.808008	2.808076	2.808143	68
643	2.808548	2.808616	2.808683	2.808751	2.808818	67
644	2.809223	2.809290	2.809358	2.809425	2.809492	6
645	2.809896	2.809963	2.810031	2.810098	2,810165	67
646	2.810568	2.810636	2,810703	2.810770	2.810837	67
647	2.811240	2.811307	2.811374	2.811441	2.811508	67
648	2.811910	2,811977	2.812044	2.812111	2,812178	67
649	2.812579	2.812646	2.812713	2.812780	2.812846	67
650	2.813247	2.813314	2.813381	2.813447	2.813514	67
651	2.813914	2.813981	2,814048	2.814114	2.814181	67
652	2.814580	2.814647	2.814714	2:814780	2.814847	67
653	2.815246	2.815312	2.815378	2.815445	2.815511	66
654	2.815910	2.815976	2.816042	2.816109	2.816175	66
655	2.816573	2.816639	2.816705	2.816771	2.816838	66
656	2.817235	2.817301	2.817367	2.817433	2.817499	66
657	2.817896	2.817962	2.818028	2.818094	2.818160	66
658	2.818556	2.818622	2.818688	2.818754	2.818819	66

A Table of Logarithms.

Num	0	1	2	3	4	*Diff*
659	2.818885	2.818951	2.819017	2.819083	2.819149	66
660	2.819544	2.819610	2.819675	2.819741	2.819807	66
661	2.820201	2.82 267	2.820333	2.820398	2.820464	66
662	2.820858	2.820924	2.820989	2.821055	2.821120	66
663	2.821513	2.821579	2.821644	2.821710	2.821775	65
664	2.822168	2.822233	2.822299	2.822364	2.822430	65
665	2.822822	2.822887	2.822952	2.823017	2.823083	65
666	2.823474	2.823539	2.823605	2.823670	2.823735	65
667	2.824126	2.824191	2.824256	2.824321	2.824386	65
668	2.824776	2.824841	2.824906	2.824971	2.825036	65
669	2.825426	2.825491	2.825556	2.825621	2.825686	65
670	2.826075	2.826140	2.826204	2.826269	2.826334	65
671	2.826722	2.826787	2.826852	2.826917	2.826981	65
672	2.827369	2.827434	2.827498	2.827563	2.827628	65
673	2.828011	2.828080	2.828144	2.828209	2.828273	64
674	2.828660	2.828724	2.828789	2.828853	2.828918	64
675	2.8 9304	2.829368	2.829432	2.829497	2.829561	64
676	2.829947	2.830011	2.830075	2.830139	2.830204	64
677	2.830589	2.830653	2 830717	2.830781	2.830845	64
678	2.831235	2.831294	2.831358	2.831422	2.831486	64
679	2.831870	2.831934	2.831998	2.832062	2.832125	64
680	2.832509	2.832573	2.832637	2.832700	2.832764	64
681	2.833147	2.833211	2.833275	2.833338	2.833402	64
682	2.833784	2.833848	2.833912	2.833975	2.834039	64
683	2.834421	2.834484	2.834548	2.834611	2.834675	64
684	2.835056	2.835120	2.835183	2.835246	2.835310	63
685	2.835691	2.835754	2.835817	2.835881	2.835944	63
686	2.836324	2.836387	2.836451	2.836514	2.836577	63
687	2·836957	2.837020	2.837083	2.837146	2.837209	63
688	2.837588	2.837652	2.837715	2.837778	2.837841	63
689	2.838219	2.838282	2.838345	2.838408	2.838471	63
690	2.838849	2.838912	2.838975	2 839038	2.839101	63
691	2.839478	2.839541	2.839604	2.839667	2.839729	63
692	2.840106	2.840169	2.840232	2.840294	2.840357	63
693	2 840733	2.840796	2.840859	2.840921	2.840984	63
694	2.841359	2.841422	2.841485	2.841547	2.841610	63
695	2.841985	2.842047	2.842110	2.842172	2.842235	62
696	2.842609	2.842672	2 842734	2.842796	2.842859	62
697	2.843233	2.843295	2.843357	2.843420	2.843482	62
698	2.843855	2.843918	2.843980	2.844042	2.844104	62
699	2.844477	2.844539	2.844601	2.844663	2.844726	62
700	2.845098	2.845160	2.845222	2.845284	2.845346	62
701	2,845718	2.845780	2.845842	2.845904	2.845966	62

Numb	5	6	7	8	9	*Diff.*
659	2.819215	2.819281	2.819346	2.819412	2.819478	66
660	2.819873	2.819939	2.820004	2.820070	2.820136	66
661	2.820530	2.820595	2.820661	2.820727	2.820792	66
662	2.821186	2.821251	2.821317	2.821382	2.821448	66
663	2.821841	2.821906	2.821972	2.822037	2.822103	65
664	2.822495	2.822560	2.822626	2.822691	2.822756	65
665	2.823148	2.823213	2.823279	2.823344	2.823409	65
666	2.823800	2.823865	2.823930	2.823996	2.824061	65
667	2.824451	2.824516	2.824581	2.824646	2.824711	65
668	2.825101	2.825166	2.825231	2.825276	2.825361	65
669	2.825751	2.825815	2.825880	2.825945	2.826010	65
670	2.826399	2.826464	2.826528	2.826593	2.826658	65
671	2.827046	2.827111	2.827175	2.827240	2.827305	65
672	2.827692	2.827757	2.827821	2.827886	2.827950	65
673	2.828338	2.828402	2.828466	2.828531	2.828595	64
674	2.828982	2.829046	2.829111	2.829175	2.829239	64
675	2.829625	2.829690	2.829754	2.829818	2.829882	64
676	2.830268	2.830332	2.830396	2.830460	2.830524	64
677	2.830909	2.830973	2.831037	2.831102	2.831166	64
678	2.831550	2.831614	2.831678	2.831742	2.831806	64
679	2.832189	2.832253	2.832317	2.832381	2.832445	64
680	2.832828	2.832892	2.832956	2.833019	2.833083	64
681	2.833466	2.833530	2.833593	2.833657	2.833721	64
682	2.834103	2.834166	2.834230	2.834293	2.834357	64
683	2.834738	2.834802	2.834866	2.834929	2.834993	64
684	2.835373	2.835437	2.835500	2.835564	2.835627	63
685	2.836007	2.836071	2.836134	2.836197	2.836261	63
686	2.836640	2.836704	2.836767	2.836830	2.836893	63
687	2.837273	2.837336	2.837399	2.837462	2.837525	63
688	2.837904	2.837967	2.838030	2.838093	2.838156	63
689	2.838534	2.838597	2.838660	2.838723	2.838786	63
690	2.839164	2.839227	2.839289	2.839354	2.839415	63
691	2.839792	2.839855	2.839918	2.839981	2.840043	63
692	2.840420	2.840482	2.840545	2.840608	2.840671	63
693	2.841046	2.841109	2.841172	2.841234	2.841297	63
694	2.841672	2.841735	2.841797	2.841860	2.841922	63
695	2.842297	2.842360	2.842422	2.842484	2.842547	62
696	2.842921	2.842983	2.843046	2.843108	2.843170	62
697	2.843544	2.843606	2.843669	2.843731	2.843793	62
698	2.844166	2.844229	2.844291	2.844353	2.844415	62
699	2.844788	2.844850	2.844912	2.844974	2.845036	62
700	2.845408	2.845470	2.845532	2.845594	2.845656	62
701	2.846028	2.846090	2.846151	2.846213	2.846275	62

Num	0	1	2	3	4	*Diff*
702	2.846337	2.846399	2.846461	2.846523	2.846584	62
703	2.846955	2.847017	2.847079	2.847141	2.847202	62
704	2.847573	2.847634	2.847696	2.847758	2.847819	62
705	2.848189	2.848251	2.848312	2.848374	2.848435	62
706	2.848805	2.848866	2.848928	2.848989	2.849051	61
707	2.849419	2.849481	2.849542	2.849604	2.849665	61
708	2.850033	2.850094	2.850156	2.850217	2.850279	61
709	2.850646	2.850707	2.850769	2.850830	2.850891	61
710	2.851258	2.851319	2.851381	2.851442	2.851503	61
711	2.851870	2.851931	2.851992	2.852053	2.852114	61
712	2.852480	2.852541	2.852602	2.852663	2.852724	61
713	2.853089	2.853150	2.853211	2.853272	2.853333	61
714	2.853698	2.853759	2.853820	2.853881	2.853941	61
715	2.854306	2.854367	2.854427	2.854488	2.854549	61
716	2.854913	2.854974	2.855034	2.855095	2.855156	61
717	2.855519	2.855580	2.855640	2.855701	2.855761	60
718	2.856124	2.856185	2.856245	2.856306	2.856366	60
719	2.856729	2.856789	2.856850	2.856910	2.856970	60
720	2.857332	2.857393	2.857453	2.857513	2.857574	60
721	2.857935	2.857995	2.858056	2.858116	2.858176	60
722	2.858537	2.858597	2,858657	2.858718	2.858778	60
723	2.859138	2.859198	2.859258	2.859318	2.859378	60
724	2,859739	2.859798	2.859858	2.859918	2.859978	60
725	2.860338	2.860398	2.860458	2.860518	2.860578	60
726	2,860937	2.860996	2.861056	2.861116	2.861176	60
727	2.861534	2,861594	2.861654	2.861714	2.861773	60
728	2.862131	2.862191	2.862251	2.862310	2.862370	60
729	2,862727	2.862787	2.862847	2.862906	2.862966	60
730	2.863323	2.863382	2.863442	2.863501	2.863561	59
731	2.863917	2.863977	2.864036	2.864096	2.864155	59
732	2.864511	2.864570	2.864630	2.864689	2.864748	59
733	2,865104	2.865163	2.865222	2,865282	2.865341	59
734	2.865693	2.865755	2.865814	2.865873	2.865933	59
735	2.866287	2.866346	2.866405	2.866465	2.866524	59
736	2.866878	2.866937	2,866996	2.867055	2.867114	59
737	2.867467	2.867526	2.867585	2,867644	2.867703	59
738	2.868056	2.868115	2.868174	2.868233	2.868292	59
739	2.868644	2.868703	2.868762	2.868821	2.868879	59
740	2.869232	2.869290	2.869349	2,869408	2.869466	59
741	2.869818	2.869877	2,869935	2.869994	2.870053	59
742	2.870404	2.870462	2.870521	2.870579	2.870638	58
743	2.870989	2.871047	2.871106	2.871164	2.871223	58
744	2.871573	2.871631	2.871690	2.871748	2.871806	58

Num	5	6	7	8	9	*Diff*
702	2.846646	2.846708	2.846770	2.846832	2.846893	62
703	2.847264	2.847326	2.847388	2.847449	2.847511	62
704	2,847881	2.847943	2.848004	2.848066	2.848127	62
705	2.848497	2,848559	2.848620	2.848682	2.848743	62
706	2.849112	2.849174	2.849235	2.849296	2.849358	61
707	2.849726	2.849788	2.849849	2,849911	2.849972	61
708	2.850340	2.850401	2.850462	2.850524	2.850585	61
709	2.850952	2.851014	2.851075	2.851136	2.851197	61
710	2.851564	2.851625	2.851686	2.851747	2.851808	61
711	2.852175	2.852236	2.852297	2.852358	2,852419	61
712	2.852785	2.852846	2.852907	2.852968	2.853029	61
713	2.853394	2.853455	2.853516	2.853576	2.853637	61
714	2.854002	2.854063	2.854134	2.854184	2.854245	61
715	2.854610	2.854670	2.854731	2.854792	2.854853	61
716	2.855216	2.855277	2.855337	2.855398	2.855459	61
717	2.855822	2.855882	2,855943	2.856003	2.856064	60
718	2.856427	2.856487	2.856548	2.856608	2.856668	60
719	2.857031	2.857091	2.857151	2.857212	2.857272	60
720	2.857634	2.857694	2.857754	2.857815	2.857875	60
721	2.858236	2.858296	2.858357	2.858417	2.858477	60
722	2.858838	2.858898	2.858958	2.859018	2.859078	60
723	2.859438	2.859498	2.859559	2.859619	2.859679	60
724	2.860038	2.860098	2.860158	2.860218	2.860278	60
725	2.860637	2.860697	2.860757	2.860817	2.860877	60
726	2.861236	2.861295	2.861355	2.861415	2.861475	60
727	2.861833	2.861893	2.861952	2.862012	2.862072	60
728	2.862430	2,862489	2.862549	2.862608	2.862668	60
729	2.863025	2.863085	2.863144	2.863204	2.863263	60
730	2·863620	2.863680	2.863739	2.863798	2.863858	59
731	2.864214	2.864274	2.864333	2.864392	2.864452	59
732	2.864808	2.864867	2.864926	2.864985	2.865045	59
733	2.865400	2.865459	2.865518	2.865578	2.865637	59
734	2.865992	2,866051	2.866110	2.866169	2.866228	59
735	2.866583	2.866642	2.866701	2.866760	2.866819	59
736	2.867173	2.867232	2.867291	2.867350	2.867409	59
737	2.867762	2.867821	2.867880	2.867939	2.867997	59
738	2.868350	2.868409	2.868468	2.868527	2.868586	59
739	2.868938	2.868997	2.869056	2.869114	2.869173	59
740	2.869525	2.869584	2.869642	2.869701	2.869760	59
741	2.870111	2.870170	2.870228	2.870287	2.870345	59
742	2.870696	2.870755	2.870813	2.870872	2.870930	58
743	2.871281	2.871339	2.871398	2,871456	2.871515	58
744	2,871865	2.871923	2,871981	2.872040	2.872098	58

Num.	0	1	2	3	4	*Diff*
745	2.872156	2.872215	2.872273	2.872331	2.872389	58
746	2.872739	2.872797	2.872855	2.872913	2.872972	58
747	2.873321	2.873379	2.873437	2.873495	2.873553	58
748	2.873902	2.873960	2.874018	2.874076	2.874134	58
749	2.874482	2.874540	2.874598	2.874656	8.874714	58
750	2.875061	2.875119	2.875177	2.875235	2.875293	58
751	2.875640	2.875698	2.875756	2.875813	2.875871	58
752	2.876218	2.876276	2.876333	2.876391	2.876449	58
753	2.876795	2.876853	2.876910	2.876968	2.877026	58
754	2.877371	2.877429	2.877486	2.877544	2.877602	58
755	2.877947	2.878004	2.878062	2.878119	2.878177	57
756	2.878522	2.878579	2.878637	2.878694	2.878751	57
757	2.879096	2.879153	2.879211	2.879268	2.879325	57
758	2.879669	2.879726	2.879784	2.879841	2.879898	57
759	2.880242	2.880299	2.880356	2.880413	2.880471	57
760	2.880814	2.880871	2.880928	2.880985	2.881042	57
761	2.881385	2.881442	2.881499	2.881556	2.881613	57
762	2.881955	2.882012	2.882069	2.882126	2.882183	57
763	2.882524	2.882581	2.882638	2.882695	2.882752	57
764	2.883093	2.883150	2.883 07	2.883264	2.883321	57
765	2.883661	2.883718	2.883775	2.883832	2.883889	57
766	2.884229	2.884285	2.884342	2.884399	2.884455	57
767	2.884795	2.884852	2.884909	2.884965	2.885022	57
768	2.885361	2.885418	2.885474	2.885531	2.885587	57
769	2.885926	2.885983	2.886039	2.886096	2.886152	56
770	2.886491	2.886547	2.886603	2.886660	2.886716	56
771	2.887054	2.887111	2.887167	2.887223	2.887280	56
772	2.887617	2.887673	2.887730	2.887786	2.887842	56
773	2.888179	2.888236	2.888292	2.888348	2.888404	56
774	2.888741	2.888797	2.888853	2.888909	2.888965	56
775	2.889302	2.889358	2.889414	2.889470	2.889526	56
776	2.889862	2.889918	2.889974	2.890030	2.890086	06
777	2.890421	2.890477	2.890533	2.890589	2.890644	56
778	2.890980	2.891035	2.891091	2.891147	2.891203	56
779	2.891537	2.891593	2.891649	2.891705	2.891760	56
780	2.892095	2.892150	2.892206	2.892262	2.892317	56
781	2.892651	2.892707	2.892762	2.892818	2.892873	56
782	2.893207	2.893262	2.893318	2.893373	2.893429	56
783	2.893762	2.893817	2.893873	2.893928	2.893984	55
784	2.894316	2.894371	2.894427	2.894482	2.894538	55
785	2.894870	2.894925	2.894980	2.895036	2.895091	55
786	2.895422	2.895478	2.895533	2.895588	2.895643	55
787	2.895975	2.896030	2.896085	2.896140	2.896195	55

Num	5	6	7	8	9	Diff
745	2.872448	2.872506	2.872564	2.872622	2.872681	58
746	2.873030	2.873088	2.873146	2.873204	2.873262	58
747	2.873611	2.873669	2.873727	2.873785	2.873843	58
748	2.874192	2.874250	2.874308	2.874366	2.874424	58
749	2.874772	2.874830	2.874887	2.874945	2.875003	58
750	2.875351	2.875409	2.875466	2.875524	2.875582	58
751	2.875929	2.875987	2 876045	2.876102	2.876160	58
752	2.876506	2.876564	2.876622	2.876680	2.876737	58
753	2.877083	2.877141	2.877198	2.877256	2.877314	58
754	2.877659	2.877717	2.877774	2.877832	2.877889	58
755	2.878234	2.878292	2.878349	2.878407	2.878464	57
756	2.878809	2.878866	2.878923	2.878981	2.879038	57
757	2.879383	2.879440	2.879497	2.879555	2.879612	57
758	2.879956	2.880013	2.880070	2.880127	2.880185	57
759	2.880528	2.880585	2.880642	2.880699	2.880756	57
760	2.881099	2.881156	2.881213	2.881270	2.881328	57
761	2.881670	2.881727	2.881784	2.881841	2.881898	57
762	2.882240	2.882297	2.882354	2.882411	2.882468	57
763	2.882809	2.882866	2.882923	2.882980	2.883036	57
764	2.883377	2.883434	2.883491	2.883548	2.883605	57
765	2.883945	2.884002	2,884059	2.884115	2.884172	57
766	2.884512	2.884569	2.884625	2.884682	2.884739	57
767	2.885078	2.885135	2.885191	2.885248	2.885305	57
768	2.885644	2.885700	2.885757	2.885813	2.885870	57
769	2.886209	2.886265	2.886321	2.886378	2.886434	56
770	2.886773	2.886829	2.886885	2.886942	2.886998	56
771	2.887336	2.887392	2.887448	2.887505	2.887561	56
772	2.887898	2.887955	2.888011	2.888067	2.888123	56
773	2.888460	2.888516	2.888573	2.888629	2.888685	56
774	2.889021	2.889077	2.889133	2.889190	2.889246	56
775	2.889582	2.889638	2.889694	2.889750	2.889806	56
776	2.890141	2.890197	2.890253	2.890309	2.890365	56
777	2.890700	2.890756	2.890812	2.890868	2.890924	56
778	2.891259	2.891314	2.891370	2.891426	2.891482	56
779	2.891816	2.891872	2,891927	2.891983	2.892039	56
780	2.892373	2.892428	2.892484	2,892540	2.892595	56
781	2.892929	2.892985	2.893040	2.893096	2.893151	56
782	2.893484	2.893540	2.893595	2.893651	2.893706	56
783	2.894039	2.894094	2.894150	2,894205	2.894261	55
784	2.894593	2.894648	2,894703	2.894759	2.894814	55
785	2.895146	2.895201	2.895257	2.895312	2.895367	55
786	2.895699	2.895754	2.895809	3.895864	2.895919	55
787	2.896251	2.896306	2.896361	2.896416	2.896471	55

Num.	0	1	2	3	4	*Diff*
788	2.896526	2.896581	2.896636	2.896691	2.896747	55
789	2.897077	2.897122	2.897187	2.897242	2.897297	55
790	2.897627	2.897682	2.897737	2.897792	2.897847	55
791	2.898176	2.898231	2.898286	2.898341	2.898396	55
792	2.898725	2.898780	2.898835	2.898890	8.898944	55
793	2.899273	2.899328	2.899383	2.899437	2.899492	55
794	2.899820	2.899875	2.899930	2.899985	2.900039	55
795	2.900367	2.900422	2.900476	2.900531	2.900586	55
796	2.900913	2.900968	2.901022	2.901077	2.901131	55
797	2.901458	2.901513	2.901567	2.901622	2.901676	54
798	2.902003	2.902057	2.902112	2.902166	2.902220	54
799	2.902547	2.902601	2.902655	2.902710	2.902764	54
800	2.903090	2.903144	2.903198	2.903253	2.903307	54
801	2.903632	2.903687	2.903741	2.903795	2.903849	54
802	2.904174	2.904228	2.904283	2.904337	2.904391	54
803	2.904715	2.904770	2.904824	2.904878	2.904932	54
804	2.905256	2.905310	2.905364	2.905418	2.905472	54
805	2.905796	2.905850	2.905904	2.905958	2.906012	54
806	2.906335	2.906389	2.905443	2.906497	2.906550	54
807	2.906873	2.906927	2.906981	2.907035	2.907089	54
808	2.907411	2.907465	2.907519	2.907573	2.907626	54
809	2.907948	2.908002	2.908056	2.908109	2.908103	54
810	2.908485	2.908539	2.908592	2.908646	2.908699	53
811	2.909021	2.909074	2.909128	2.909181	2.909235	53
812	2.909556	2.909609	2.909663	2.900716	2.909770	53
813	2.910090	2.910144	2.910197	2.910251	2.910304	53
814	2.910624	2.910678	2.910731	2.910784	2.910838	53
815	2.911158	2.911211	2.911264	2.911317	2.911371	53
816	2.911690	2.911743	2.911797	2.911850	2.911903	53
817	2.912222	2.912275	2.912328	2.912381	2.912435	53
818	2.912753	2.912806	2.912859	2.912912	2.912966	53
819	2.913284	2.913337	2.913390	2.913443	2.913496	53
820	2.913814	2.913867	2.913920	2.913973	2.914026	53
821	2.914343	2.914396	2.914449	2.914502	2.914555	53
822	2.914872	2.914925	2.914977	2.915030	2.915083	53
823	2.915400	2.915453	2.915505	2.915558	2.915611	53
824	2.915927	2.915980	2.916033	2.916085	2.916138	53
825	2.916454	2.916507	2.916559	2.916612	2.916664	53
826	2.916980	2.917033	2.917085	2.917138	2.917190	53
827	2.917505	2.917558	2.917610	2.917663	2.917715	52
828	2.918030	2.918083	2.918135	2.918188	2.918240	52
829	2.918555	2.918607	2.918659	2.918712	2.918764	52
830	2.919078	2.919130	2.919183	2.919235	2.919287	52

Num	5	6	7	8	9	Diff
788	2.896802	2.896857	2.896912	2.896967	2.897022	55
789	2.897352	2.897407	2.897462	2.897517	2.897572	55
790	2.897902	2.897957	2.898012	2.898067	2.898122	55
791	2,898451	2 898506	2.898561	2.898615	2.898670	55
792	2.898999	2 899054	2.899109	2.899164	2.899218	55
793	2 899547	2.899602	2.899656	2.899711	2 899766	55
794	2.900094	2.900149	2.900203	2.900258	2.900312	55
795	2.900640	2.900695	2.900749	2.900804	2.900858	55
796	2.901186	2.901240	2.901295	2.901349	2.901404	55
797	2.901731	2.901785	2.901840	2.901894	2.901948	54
798	2.902275	2.902329	2.902384	2.902438	2.902492	54
799	2.902818	2.902873	2.902927	2.902981	2.903036	54
800	2.903361	2.903416	2.903470	2.903524	2.903578	54
801	2.903903	2.903958	2.904012	2.904066	2.904120	54
802	2.904445	2.904499	2.904553	2.904607	2.904661	54
803	2.904986	2.905040	2.905094	2.905148	2.905202	54
804	2.905526	2.905580	2.905634	2.905688	2.905742	54
805	2.906065	2.906119	2.906173	2.906227	2.906281	54
806	2.906604	2.906658	2.906712	2.906766	2.906820	54
807	2.907142	2.907196	2 907250	2.907304	2.907358	54
808	2.907680	2.907734	2.907787	2.907841	2.907895	54
809	2.908217	2.908270	2.908324	2.908378	2.908431	54
810	2.908753	2.908807	2.908860	2.908914	2.908967	54
811	2.909288	2.909342	2.909395	2.909449	2.909502	54
812	2.909823	2.909877	2.909930	2.909984	2.910037	53
813	2.910358	2.910411	2.910464	2.910518	2.910571	53
814	2.910891	2.910944	2.910998	2.911051	2.911104	53
815	2.911424	2.911477	2.911530	2.911584	2.911637	53
816	2.911956	2.912009	2.912063	2.912116	2.912169	53
817	2.912488	2.912541	2.912594	2.912647	2.912700	53
818	2.913019	2.913072	2 913125	2.913178	2.913231	53
819	2.913549	2.913602	2.913655	2.913708	2.913761	53
820	2.914079	2.914131	2.914184	2.914237	2.914290	53
821	2.914608	2.914660	2.914713	2.914766	2.914819	53
822	2.915136	2,915189	2.915241	2.915294	2.915347	53
823	2.915664	2.915716	2.915769	2.915822	2.915874	53
824	2.916191	2.916243	2.916296	2.916349	2.916401	53
825	2.916717	2.916770	2,916822	2.916875	2.916927	53
826	2.917243	2.917295	2.917348	2.917400	2.917453	53
827	2.917768	2.917820	2.917873	2.917925	2.917978	52
828	2.918292	2.918345	2.918397	2.918450	2.918502	52
829	2.918816	2.918869	2.918921	2.918973	2 919026	52
830	2.919340	2.919392	2.919444	2.919496	2.919549	52

Num	0	1	2	3	4	Diff.
831	2.919601	2.919653	2.919705	2.919758	2.919810	52
832	2.920123	2.920175	2.920228	2.920280	2.920332	52
833	2.920645	2.920697	2.920749	2.920801	2.920853	52
834	2.921166	2.921218	2.921270	2.921322	2.921374	52
835	2.921686	2.921738	2.921790	2.921842	2.921894	52
836	2.922206	2.922258	2.922310	2.922362	2.922414	52
837	2.922725	2.922777	2.922829	2.922881	2.922933	52
838	2.923244	2.923296	2.923348	2.923399	2.923451	52
839	2.923762	2.923814	2.923865	2.923917	2.923969	52
840	2.924279	2.924331	2.924383	2.924434	2.924486	52
841	2.924796	2.924848	2.924899	2.924951	2.925002	52
842	2.925312	2.925364	2.925415	2.925467	2.925518	52
843	2.925828	2.925879	2.925931	2.925982	2.926034	51
844	2.926342	2.926394	2.926445	2,926497	2.926548	51
845	2.926857	2.926908	2.926959	2.927011	2.927062	51
846	2.927370	2.927422	2.927473	2.927524	2.927576	51
847	2.927883	2.927935	2.927986	2.928037	2.928088	51
848	2.928396	2.928447	2.928498	2.928549	2.928601	51
849	2.928908	2.928959	2.929010	2.929061	2.929112	51
850	2.929419	2.929470	2.929521	2.929572	2.929623	51
851	2.929930	2.929981	2.930032	2.930083	2,930134	51
852	2.930440	2.930491	2.930541	2.930592	2.930643	51
853	2.930949	2.931000	2.931051	2.931102	2.931153	51
854	2.931458	2.931509	2.931560	2.931610	2.931661	51
855	2.931966	2.932017	2.932068	2.932118	2.932169	51
856	2.932474	2.932524	2.932575	2.932626	2.932677	51
857	2.932981	2.933031	2.933082	2.933133	2.933183	51
858	2.933487	2.933538	2.933588	2.933639	2,933690	51
859	2.933993	2.934044	2.934094	2.934145	2.934195	51
860	2.934498	2.934549	2.934599	2.934650	2.934700	50
861	2.935003	2.935054	2 935104	2.935154	2.935205	50
862	2.935507	2.935558	2.935608	2.935658	2.935709	50
863	2.936011	2.936061	2.936111	2.936161	2.936211	50
864	2.936514	2.936564	2.936614	2.936664	2.936715	50
865	2.937016	2.937066	2.937116	2.937167	2.937217	50
866	2.937518	2.937568	2.937618	2.937668	2.937718	50
867	2.938019	2.938069	2.938119	2.938169	2.938219	50
868	2.938520	2.938570	2.938620	2.938670	2.938720	50
869	2.939020	2.939070	2.939120	2.939170	2.939220	50
870	2.939519	2.939569	2.939619	2.939669	2.939719	50
871	2.940018	2.940068	2.940118	2.940168	2.940218	50
872	2.940516	2.940566	2.940616	2 940666	2.940716	50
873	2.941014	2,941064	2.941114	2.941163	2.941213	50

Num	5	6	7	8	9	*Diff*
831	2,919862	2.919914	2.919967	2.920019	2.920071	52
832	2.920384	2.920436	2.920489	2.920541	2.920593	52
833	2.920906	2.920958	2.921010	2.921062	2.921114	52
834	2.921426	2.921478	2.921530	2.921582	2.921634	52
835	2.921946	2.921998	2.922050	2.922102	2.922154	52
836	2.922466	2.922518	2.922570	2.922622	2.922674	52
837	2.922985	2.923037	2.923088	2.923140	2.923192	52
838	2.923503	2.923555	2.923607	2.923658	2.923710	52
839	2.924021	2.924072	2.924124	2.924176	2.924228	52
840	2.924538	2.924589	2.924641	2.924693	2.924744	52
841	2.925054	2.925106	2.925157	2.925209	2.925260	52
842	2.925570	2.925621	2.925673	2.925724	2.925776	52
843	2.926085	2.926137	2.926188	2.926239	2.926 91	52
844	2.926600	2.926651	2.926702	2.926754	2.926805	52
845	2.927114	2.927165	2.927216	2.927268	2.927319	52
846	2.927627	2.927678	2.927730	2.927781	2.927832	52
847	2.928140	2.928191	2.928242	2.928293	2.928345	52
848	2.928652	2.928703	2.928754	2.928805	2.928856	51
849	2.929163	2.929214	2.929266	2.929317	2.929368	51
850	2.929674	2.929725	2.929776	2.929827	2.929878	51
851	2.930185	2.930236	2.930287	2.930338	2.930389	51
852	2.930694	2.930745	2.930796	2.930847	2.930898	51
853	2.931203	2.931254	2.931305	2.931356	2.931407	51
854	2.931712	2.931763	2.931814	2.931864	2.931915	51
855	2.932220	2.932271	2.932321	2.932372	2.932423	51
856	2.932727	2.932778	2.932829	2.932879	2.932930	51
857	2.933234	2.933285	2.933335	2.933386	2.933437	51
858	2.933740	2.933791	2.933841	2.933892	2.933943	51
859	2.934246	2.934296	2.934347	2.934397	2.934448	51
860	2.934751	2.934801	2.934852	2.934902	2.934953	50
861	2.935255	2.935306	2.935356	2.935406	2.935457	50
862	2.935759	2.935809	2.935860	2.935910	2.935960	50
863	2.936262	2.936313	2.936363	2.936413	2.936463	50
864	2.936765	2.936815	2.936865	2.936916	2.936966	50
865	2.937267	2,937317	2.937367	2.937418	2.937468	50
866	2.937769	2.937819	2.937869	2.937919	2.937969	50
867	2.938269	2.938319	2.938370	2.938420	2.938470	50
868	2.938770	2.938820	2.938870	2.938920	2.938970	50
869	2.939270	2.939319	2.939369	2.939419	2.939469	50
870	2.939769	2.939819	2.939868	2.939918	2.939968	50
871	2.940267	2.940317	2.940367	2.940417	2.940467	50
872	2.940765	2.940815	2.940865	2.940915	2.940965	50
873	2.941263	2.941313	2.941362	2.941412	2.941462	50

Num.	0	1	2	3	4	*Diff*
874	2.941511	2.941561	2.941611	2.941600	2.941710	50
875	2.942008	2.942058	2.942107	2.942157	2.942206	50
876	2.942504	2.942554	2.942604	2.942653	2.942702	50
877	2.943000	2.943049	2.943099	2.943148	2.943198	49
878	2.943494	2.943544	2.943593	2.943643	2.943692	49
879	2.943989	2.944038	2.944088	2.944137	2.944186	49
880	2.944483	2.944532	2.944581	2.944631	2.944680	49
881	2.944976	2.945025	2.945074	2.945124	2.945173	49
882	2.945469	2.945518	2.945567	2.945616	2.945665	49
883	2.945961	2.946010	2.946059	2.946108	2.946157	49
884	2.946452	2.946501	2.946550	2.946600	2.946649	49
885	2.946943	2.946992	2.947041	2.947090	2.947139	49
886	2.947434	2.947483	2.947532	2.947581	2.947630	49
887	2.947924	2.947973	2.948021	2.948070	2.948119	49
888	2.948413	2.948462	2.948511	2.948560	2.948609	49
889	2.948902	2.948951	2.948999	2.949048	2.949097	49
890	2.949390	2.949439	2.949488	2.949536	2.949585	49
891	2.949878	2.949926	2.949975	2.950024	2.950073	49
892	2.950365	2.950413	2.950462	2.950511	2.950560	49
893	2.950851	2.950900	2.950949	2.950998	2.951046	49
894	2.951337	2.951386	2.951435	2.951483	2.951532	49
895	2.951823	2.951872	2.951920	2.951969	2.952017	49
896	2.952308	2.952356	2.952405	2.952453	2.952502	48
897	2.952792	2.952841	2.952889	2.952938	2.952986	48
898	2.953276	2.953325	2.953373	2.953421	2.953470	48
899	2.953760	2.953808	2.953856	2.953905	2.953953	48
900	2.954242	2.954291	2.954339	2.954387	2.954435	48
901	2.954725	2.954773	2.954821	2.954869	2.954918	48
902	2.955206	2.955255	2.955303	2.955351	2.955399	48
903	2.955688	2.955736	2.955784	2.955832	2.955880	48
904	2.956168	2.956216	2.956264	2.956312	2.956360	48
905	2.956649	2.956697	2.956745	2.956792	2.956840	48
906	2.957128	2.957176	2.957224	2.957272	2.957320	48
907	2.957607	2.957655	2.957703	2.957751	2.957799	48
908	2.958086	2.958134	2.958181	2.958229	2.958277	48
909	2.958564	2.958612	2.958659	2.958707	2.958755	48
910	2.959041	2.959089	2.959137	2.959184	2.959232	48
911	2.959518	2.959566	2.959614	2.959661	2.959709	48
912	2.959995	2.960042	2.960090	2,960138	2.960185	48
913	2.960471	2.960518	2.960566	2.960612	2.960661	48
914	2.960946	2.960994	2.961041	2.961089	2.961136	47
915	2.961421	2.961468	2.961516	2.961563	2.961611	47
916	2.961895	2.961943	2.961990	2.962038	2.962085	47

Num	5	6	7	8	9	Diff
874	2.941760	2.941809	2.941859	2.941909	2.941958	50
875	2.942256	2.942306	2.942355	2.942405	2.942454	50
876	2.942752	2.942801	2.942851	2.942900	2.942950	50
877	2.943247	2.943297	2.943346	2.943396	2.943445	49
878	2.943742	2.943791	2.943841	2.943890	2.943939	49
879	2.944236	2.944285	2.944335	2.944384	2.944433	49
880	2.944729	2.944779	2.944828	2.944877	2.944927	49
881	2.945222	2.945272	2.945321	2.945370	2.945419	49
882	2.945715	2.945764	3.945813	2.945862	2.945911	49
883	2.946207	2.946256	2.946305	2.946354	2.946403	49
884	2.946698	2.946747	2.946796	2.946845	2.946894	49
885	2.947189	2.947238	2.947287	2.947336	2.947385	49
886	2.947679	2.947728	2.947777	2.947826	2.947875	49
887	2.948168	2.948217	2.948266	2.948315	2.948364	49
888	2.948657	2.948706	2.948755	2.948804	2.948853	49
889	2.949146	2.949195	2.949244	2.949292	2.949341	49
890	2.949633	2.949683	2.949731	2.949780	2.949829	49
891	2.950121	2.950170	2.950219	2.950267	2.950316	49
892	2.950608	2.950657	2.950705	2.950754	2.950803	49
893	2.951095	2.951143	2.951192	2.951240	2.951289	49
894	2.951580	2.951629	2.951677	2.951726	2.951774	49
895	2.952066	2.952114	2.952163	2.952211	2.952259	48
896	2.952550	2.952599	2.952647	2.952696	2.952744	48
897	2.953034	2.953083	2.953131	2.953180	2.953228	48
898	2.953518	2.953566	2.953615	2.953663	2.953711	48
899	2.954001	2.954049	2.954098	2.954146	2.954194	48
900	2.954484	2.954532	2.954580	2.954628	2.954677	48
901	2.954966	2.955014	2.955062	2.955110	2.955158	48
902	2.955447	2.955495	2.955543	2.955591	2.955640	48
903	2.955928	2.955976	2.956024	2.956072	2.956120	48
904	2.956409	2.956457	2.956505	2.956553	2.956601	48
905	2.956888	2.956936	2.956984	2.957032	2.957080	48
906	2.957368	2.957416	2.957464	2.957511	2.957559	48
907	2.957847	2.957894	2.957942	2.957990	2.958038	48
908	2.958325	2.958373	2.958420	2.958468	2.958516	48
909	2.958803	2.958850	2.958898	2,958946	2.958994	48
910	2.959280	2.959328	2.959375	2.959423	2.959471	48
911	2.959757	2.959804	2.959852	2.959900	2.959947	48
912	2.960233	2.960208	2.960328	2,960376	2.960423	48
913	2.960708	2.960756	2.960804	2.960851	2.960899	48
914	2.961184	2.961231	2.961279	2.961326	2.961374	47
915	2.961658	2.961706	2.961753	2.961801	2.961848	47
916	2.962132	2.962180	2,962227	2.962275	2.962322	47

Num	5	6	7	8	9	*Diff*
917	2.962369	2.962417	2.962464	2.962511	2.962559	47
918	2.962843	2.962890	2.962937	2.962985	2.963032	47
919	2.963315	2.963363	2.963410	2.963457	2.963504	47
920	2.963788	2.963835	2.963882	2.963929	2.963977	47
921	2.964260	2.964307	2.964354	2.964401	2.964448	47
922	2.964731	2.964778	2.964825	2.964872	2.964919	47
923	2.965202	2.965249	2.965296	2.965343	2.965390	47
924	2.965672	2.965719	2.965766	2.965813	2.965860	47
925	2.966142	2.966189	3.966236	2.966283	2.966329	47
926	2.966611	2.966658	2.966705	2.966752	2.966798	47
927	2.967080	2.967127	2.967173	2.967220	2.967267	47
928	2.967548	2.967595	2.967642	2.967688	2.967735	47
929	2.968016	2.968062	2.968109	2.968156	2.968203	47
930	2.968483	2.968530	2.968576	2.968623	2.968670	47
931	2.968950	2.968996	2.969043	2.969090	2.969136	47
932	2.969416	2.969462	2.969509	2.969556	2.969602	47
933	2.969882	2.969928	2.969975	2.970021	2.970068	47
934	2.970347	2.970393	2.970440	2.970486	2.970533	46
935	2.970812	2.970858	2.970904	2.970951	2.970997	46
936	2.971276	2.971322	2.971369	2.971415	2.971461	46
937	2.971740	2.971786	2.971832	2.971879	2.971925	46
938	2.972203	2.972249	2.972295	2.972342	2.972388	46
939	2.972666	2.972712	2.972758	2.972804	2.972851	46
940	2.973128	2.973174	2.973220	2.973266	2.973313	46
941	2.973590	2.973636	2.973682	2.973728	2.973774	46
942	2.974051	2.974097	2.974143	2.974189	2 974235	46
943	2.974512	2.974558	2.974604	2.974650	2.974696	46
944	2.974972	2.975018	2.975064	2.975110	2.975156	46
945	2.975432	2.975478	2.975524	2.975570	2.975616	46
946	2.975891	2.975937	2.975983	2.976029	2.976075	46
947	2.976350	2.976396	2.976442	2.976487	2.976533	46
948	2.976808	2.976854	2.976900	2,976946	2 976991	46
949	2.977266	2.977312	2.977358	2.977403	2 977449	46
950	2.977724	2.977769	2.977815	2.977861	2.977906	46
951	2.978180	2.978226	2.978272	2.978317	2 978363	46
952	2.978637	2.978683	2.978728	2,978774	2.978819	46
953	2.979093	2.979138	2 979184	2.979230	2.979275	46
954	2.979548	2.979594	2.979639	2.979685	2.979730	46
955	2.980003	2.980049	2.980094	2,980140	2.980185	45
956	2.980458	2.980503	2.980549	2.980594	2 980640	45
957	2.980912	2.980957	2.981003	2.981048	2.981093	45
958	2.981365	2.981411	2.981456	2.981501	2.981547	45
959	2.981819	2.981864	2,981909	2.981954	2 982000	45

Num.	0	1	2	3	4	Diff
917	2,962606	2.962653	2.962701	2.962748	2.962795	47
918	2.963079	2.963126	2.963174	2.963221	2.963268	47
919	2.963552	2.963599	2.963646	2.963693	2.963741	47
920	2.964024	2.964071	2.964118	2.964165	2.964212	47
921	2.964495	2.964542	2.964590	2.964637	2.964684	47
922	2.964966	2.965013	2.965060	2.965108	2.965155	47
923	2.965437	2.965484	2.965531	2.965578	2.965625	47
924	2.965907	2.965954	2.966001	2.966048	2.966095	47
925	2.966376	2.966423	2.966470	2.966517	2.966564	47
926	2.966845	2.966892	2.966939	2.966986	2.967033	47
927	2.967314	2.967361	2.967408	2.967454	2.967501	47
928	2.967782	2.967829	2.967875	2.967922	2.967969	47
929	2.968249	2.968296	2.968343	2.968389	2.968436	47
930	2.968716	2.968763	2.968810	2.968856	2.968903	47
931	2.969183	2.969229	2.969276	2.969323	2.969369	47
932	2.969649	2.969695	2.969742	2.969788	2.969835	47
933	2.970114	2.970161	2.970207	2.970254	2.970300	47
934	2.970579	2.970626	2.970672	2.970719	2.970765	47
935	2.971044	2.971090	2.971137	2.971183	2.971229	46
936	2.971508	2.971554	2.971600	2.971647	2.971693	46
937	2.971971	2.972018	2.972064	2.972110	2.972156	46
938	2.972434	2.972480	2.972527	2.972573	2.972619	46
939	2.972897	2.972943	2.972989	2.973035	2.973082	46
940	2.973359	2.973405	2.973451	2.973497	2.973543	46
941	2.973820	2.973866	2.973913	2.973959	2.974005	46
942	2.974281	2.974327	2.974373	2.974420	2.974466	46
943	2.974742	2.974788	2.974834	2.974880	2.974926	46
944	2.975202	2.975248	2.975294	2.975340	2.975386	46
945	2.975661	2.975707	2.975753	2.975799	2.975845	46
946	2.976121	2.976166	2.976212	2.976258	2.976304	46
947	2.976579	2.976625	2.976671	2.976717	2.976762	46
948	2.977037	2.977083	2.977129	2.977175	2.977220	46
949	2.977495	2.977541	2.977586	2.977632	2.977678	46
950	2.977952	2.977998	2.978043	2.978089	2.978135	46
951	2.978409	2,978454	2.978500	2.978546	2.978591	46
952	2.978865	2.978911	2.978956	2.979002	2.979047	46
953	2.979321	2.979366	2.979412	2.979457	2.979503	46
954	2.979776	2.979821	2.979867	2.979912	2.979958	46
955	2.980231	2.980276	2.980322	2.980367	2.980412	45
956	2.980685	2.980730	2.980776	2.980821	2.980867	45
957	2.981139	2.981184	2.981229	2.981275	2.981320	45
958	2,981592	2.981637	2.981683	2.981728	2.981773	45
959	2.982045	2.982090	2,982135	2.982181	2.982226	45

Num	0	1	2	3	4	*Diff*
960	2.982271	2.982316	2.982362	2.982407	2.982452	45
961	2.982723	2.982769	2.982814	2.982859	2.982904	45
962	2.983175	2.983220	2.983265	2.983310	2.983356	45
963	2.983626	2.983671	2.983716	2.983762	2.983807	45
964	2.984077	2.984122	2.984167	2.984212	2.984257	45
965	2.984527	2.984572	2.984617	2.984662	2.984707	45
966	2.984977	2.985022	2.985067	2.985112	2.985157	45
967	2.985426	2.985471	2.985516	2.985561	2.985606	45
968	2.985875	2.985920	2.985965	2.986010	2.986055	45
969	2.986324	2.986369	2.986413	2.986458	2.986503	45
970	2.986772	2.986816	2.985801	2.986906	2.986951	45
971	2.987219	2.987264	2.987309	2.987353	2.987398	45
972	2.987666	2.987711	2.987756	2 987800	2.987845	45
973	2.988113	2.988157	2.988202	2,988247	2.988291	45
974	2.988559	2.988603	2.988648	2.988693	2.988737	45
975	2.989005	2.989049	2.989094	2.989138	2.989183	45
976	2.989450	2.989494	2.989539	2.989583	2.989628	44
977	2.989895	2.989939	2.989983	2,990028	2.990072	44
978	2.990339	2.990383	2.990428	2.990472	2.990516	44
979	2.990783	2.990827	2.990871	2.990916	2'990960	44
980	2,991226	2.991270	2.991315	2.991359	2,991403	44
981	2.991669	2.991713	2.991757	2.991802	2.991846	44
982	2.992111	2.992156	2.992200	2.992244	2.992289	44
983	2.992553	2.992598	2.992642	2.992686	2.992730	44
984	2.992995	2.993039	2.993083	2.993127	2.993172	44
985	2.993436	2.993480	2.993524	2.993568	2.993613	44
986	2.993877	2.993921	2.993965	2.994009	2.994053	44
987	2.994317	2.994361	2.994405	2.994449	2,994493	44
988	2.994757	2.994801	2.994845	2.994889	2.994933	44
989	2.995196	2.995240	2.995284	2.995328	2.995372	44
990	2.995635	2.995679	2 995723	2.995767	2.995811	44
991	2.996074	2.996117	2.996161	2.996205	2.996249	44
992	2.996512	2.996555	2.995599	2.996643	2.996687	44
993	2.996949	2.996993	2.997037	2.997080	2.997124	44
994	2.997386	2.997430	2.997474	2.997517	2.997561	44
995	2.997823	2.997867	2.997910	2.997954	2.997998	44
996	2.998259	2.998303	2.998346	2.998390	2.998432	44
997	2.998695	2.998739	2.998782	2.998826	2.998869	44
998	2.999130	2.999174	2.999218	2.999261	2.999305	44
999	2.999565	2.999609	2.999652	2.999696	2.999739	43

Num.	5	6	7	8	9	Diff.
960	2,982497	2.982543	2.982588	2.982633	2.982678	45
961	2.982949	2.982994	2.983040	2.983085	2.983130	45
962	2.983401	2.983446	2.983491	2.983536	2.983581	45
963	2.983852	2.983897	2.983942	2.983987	2.984032	45
964	2.984302	2.984347	2.984392	2.984437	2.984482	45
965	2.984752	2.984797	2.984842	2.984887	2.984932	45
966	2.985202	2.985247	2.985292	2.985337	2.985382	45
967	2.985651	2.985696	2.985741	2.985786	2.985830	45
968	2.986100	2.986144	2.986189	2.986234	2.986279	45
969	2.986548	2.986593	2.986637	2.986682	2.986727	45
970	2.986995	2.987040	2.987085	2.987130	2.987174	45
971	2.987443	2.987487	2.987532	2.987577	2.987622	45
972	2.987890	2.987934	2.987979	2.988024	2.988068	45
973	2.988336	2.988381	2.988425	2.988470	2.988514	45
974	2.988782	2.988826	2.988871	2.988915	2.988960	45
975	2.989227	2.989272	2.989316	2.989361	2.989405	45
976	2.989672	2.989717	2.989761	2.989806	2.989850	44
977	2.990117	2.990161	2.990206	2.990250	2.990294	44
978	2.990561	2.990605	2.990650	2.990694	2.990738	44
979	2.991004	2.991049	2.991093	2.991137	2.991182	44
980	2.991448	2.991492	2.991536	2.991580	2.991625	44
981	2.991890	2.991934	2.991979	2.992023	2.992067	44
982	2.992333	2.992377	2.992421	2.992465	2.992509	44
983	2.992774	2.992818	2.992863	2.992907	2.992951	44
984	2.993216	2.993260	2.993304	2.993348	2.993392	44
985	2.993657	2.993701	2.993745	2.993789	2.993833	44
986	2.994097	2.994141	2.994185	2.994229	2.994273	44
987	2.994537	2.994581	2.994625	2.994669	2.994713	44
988	2.994977	2.995021	2.995064	2.995108	2.995152	44
989	2.995416	2.995460	2.995504	2.995547	2.995591	44
990	2.995854	2.995898	2.995942	2.995986	2.996030	44
991	2.996293	2.996336	2.996380	2.996424	2.996468	44
992	2.996730	2.996774	2.996818	2.996862	2.996905	44
993	2.997168	2.997212	2.997255	2.997299	2.997343	44
994	2.997605	2,997648	2.997692	2.997736	2.997779	44
995	2.998041	2.998085	2.998128	2.998172	2.998216	44
996	2.998477	2.998521	2.998564	2.998608	2.998652	44
997	2.998913	2.998956	2.999000	2.999043	2.999087	44
998	2.999348	2.999392	2.999435	2.999478	2.999522	44
999	2.999783	2.999826	2.999870	2.999913	2.999957	44

0 *Degrees*

Minutes	Sine		Tangent		Secant		
0	0.000000	10.000000	0,000000	Infinite	10.000000	Infinite	60
1	6.463726	9.999999	6.463726	13.536274	10.000000	13.536274	59
2	6.764756	9.999999	6.764756	13.235244	10.000000	13.235244	58
3	0.940847	9.999999	6.940847	13.059152	10.000000	13.059153	57
4	7.065786	9.999999	7.065786	12.934214	10.000000	12.934214	56
5	7.162696	9.999999	7.162696	12.837304	10.000000	12.837304	55
6	7.241877	9.999999	7.241878	12.758122	10.000001	12.758123	54
7	7.308824	9.999999	7.308825	12.691175	10.000001	12.691176	53
8	7.366816	9.999999	7.366817	12.633183	10.00000	12.633184	52
9	7.417968	9.999998	7.417970	12.582030	10.000001	12.582032	51
10	7.463725	9.999998	7.463727	12.536273	10.000002	12.536274	50
11	7.505118	9.999998	7.505120	12.494880	10.000002	12.494882	49
12	7.542906	9.999997	7.542909	12.457091	10.000003	12.457093	48
13	7.577667	9.999997	7.577671	12 422328	10.000003	12.422333	47
14	7.609853	9.999996	7.609857	12.390143	10.000004	12.390147	46
15	7.639816	9.999996	7.639820	12.360180	10.000004	12.360184	45
16	7.667844	9.999995	7.667849	12.332151	10.000005	12.332156	44
17	7.694173	9.999995	7.694179	12.305821	10.000005	12.305827	43
18	7.718997	9.999994	7.719003	12.280997	10.000006	12.281003	42
19	7.742477	9.999993	7.742484	12.257516	10.000007	12.257523	41
20	7.764754	9.999993	7.764761	12.235239	10.000007	12.235246	40
21	7.785943	9.999992	7.785951	12.214049	10.000008	12.214057	39
22	7.806146	9.999991	7.806155	12.193845	10.000009	12.193854	38
23	7.825451	9.999990	7.825460	12.174540	10.000010	12.174549	37
24	7.843934	9.999989	7.843944	12.156056	10.000011	12.156066	36
25	7.861662	9.999988	7.861674	12.138326	10.000012	12.138338	35
26	7.878695	9.999988	7.878708	12.121292	10.000012	12.121305	34
27	7.895085	9.999987	7.895099	12.104901	10.000013	12.104915	33
28	7.910879	9.999986	7.910894	12.089106	10.000014	12.089121	32
29	7.926119	9.999984	7.926134	12.073866	10.000016	12.073881	31
30	7.940842	9.999983	7.940858	12.059142	10.000017	12.059158	30
		Sine		Tangent		Secant	Minutes

89 *Degrees.*

0 Degrees.

Minutes	Sine		Tangent		Secant		
30	7.940842	9.999983	7.940858	12.059142	10.000016	12.059158	30
31	7.955082	9.999982	7.955100	12.044900	10.000018	12.044918	29
32	7.968870	9.999981	7.968889	12.031111	10.000019	12.031130	28
33	7.982233	9.999980	7.982253	12.017747	10.000020	12.017767	27
34	7.995198	9.999979	7.995219	12.004781	10.000021	12.004802	26
35	8.007787	9.999977	8.007809	11.992191	10.000022	11.992213	25
36	8.020021	9.999976	8.020044	11.979956	10.000024	11.979979	24
37	8.031919	9.999975	8.031945	11.968055	10.000025	11.968080	23
38	8.043501	9.999973	8 043527	11.956473	10.000027	11.956499	22
39	8.054781	9 999972	8.054809	11.945191	10.000028	11.945219	21
40	8,065776	9.999971	8.065806	11.934194	10.000029	11.934224	20
41	8-076500	9.999969	8.076531	11.923469	10.000031	11.923500	19
42	8.086965	9.999968	8.086997	11.913003	10.000032	11.913035	18
43	8.097183	9.999966	8.097217	11.902783	10.000034	11.902817	17
44	8.107167	9.999964	8.107202	11.892798	10.000037	11.892833	16
45	8.116926	9.999963	8.116963	11.883037	10.000037	11.883074	15
46	8.126471	9.999961	8.126510	11.873490	10.000039	11.873529	14
47	8.135810	9.999959	8.135851	11.864149	10.000041	11.864190	13
48	8.144953	9.999958	8.144996	11.855004	10.000042	11.855047	12
49	8.153907	9.999956	8.153952	11.846048	10.000044	11.846093	11
50	8.162681	9.999954	8.162727	11.837273	10.000046	11:837319	10
51	8-171280	9.999952	8.171328	11.828672	10.000048	11.828720	9
52	8,179713	9.999950	8.179763	11.820237	10.000050	11.820287	8
53	8,187985	9.999948	8.188036	11.811964	10.000052	11.812015	7
54	8.196102	9.999946	8.196156	11.803844	10.000054	11.803898	6
55	8.204070	9.999944	8.204126	11.795874	10.000056	11.795930	5
56	8.211895	9.999942	8.211953	11.788047	10.000058	11.788105	4
57	8.219581	9.999940	8.219641	11.780359	10.000060	11.780419	3
58	8.227133	9.999938	8.227195	11.772805	10.000062	11.772866	2
59	8.234557	9.999936	8.234621	11.765379	10.000064	11.765443	1
60	8.241855	9.999934	8.241921	11.758079	10.000066	11.758145	0
		Sine		Tangent		Secant	Minutes

89 Degrees.

1 *Degree.*

Minutes	Sine		Tangent		Secant		
0	8.241855	9.999934	8.241921	11.758079	10.000066	11.758145	60
1	8.249033	9.999932	8.249101	11.750899	10.000068	11.750967	59
2	8.256094	9.999929	8.256165	11.743835	10.000071	11.743906	58
3	8.263042	9.999927	8.263115	11.736885	10.000073	11.736958	57
4	8,269881	9.999925	8.269956	11.730044	10.000075	11.730119	56
5	8.276614	9.999922	8.276691	11.723309	10.000078	11.723386	55
6	8.283243	9.999920	8.283323	11.716677	10.000080	11.716757	54
7	8,289773	9.999917	8.289856	11.710144	10.000082	11.710227	53
8	8-296207	9.999915	8.296292	11.703708	10.000085	11.703793	52
9	8.302546	9.999912	8.302633	11.697367	10.000087	11.697454	51
10	8.308794	9.999910	8.308884	11.691116	10.000090	11.691206	50
11	8.314954	9.999907	8.315046	11.684954	10.000093	11.685046	49
12	8.321027	9.999905	8.321122	11.678878	10.000095	11.678973	48
13	8.327016	9.999902	8.327114	11.672886	10.000098	11.672984	47
14	8.332924	9.999899	8 333025	11.666975	10.000101	11.667076	46
15	8.338753	9.999897	8.338856	11.661144	10.000103	11.661247	45
16	8.344504	9.999894	8.344610	11.655389	10.000106	11.655498	44
17	8.350180	9.999891	8.350289	11.649710	10.000109	11.649819	43
18	8.355783	9.999888	8.355895	11.644105	10.000112	11.644216	42
19	8.361315	9.999885	8.361430	11.638570	10.000115	11.638685	41
20	8.366777	9.999882	8.366894	11.633105	10.000118	11:633223	40
21	8.372171	9.999876	8.372291	11.627708	10.000121	11.627829	39
22	8,377499	9.999879	8.377622	11.622378	10.000124	11.622501	38
23	8-382762	9.999873	8.382889	11.617111	10.000127	11.617238	37
24	8.387962	9.999870	8.388092	11.611908	10.000130	11.612038	36
25	8.393101	9.999867	8.393234	1 .606766	10.000133	11.606899	35
26	8.398179	9.999864	8.398315	11.601685	10.000136	11.601821	34
27	8.403199	9.999861	8.403338	11.596662	10.000139	11.596801	33
28	8.408161	9.999858	8.408304	11.591696	10.000142	11.591839	32
29	8.413068	9.999854	8.413213	11.586787	10.000146	11.586931	31
30	8.417919	9.999851	8.418068	11.581932	10.000149	11.582081	30
		Sine		Tangent		Secant	Minntes

88 *Degrees.*

1 Degree.

Minutes	Sine		Tangent		Secant		
30	8.417919	9.999851	8.418068	11.581932	10.000149	11.582081	30
31	8.422717	9.999848	8.422869	11.577131	10.000152	11.577283	29
32	8.427462	9.999844	8.427618	11.572382	10.000155	11.572538	28
33	8.432156	9.999841	8.432315	11.567685	10.000159	11.567844	27
34	8.436800	9.999838	8.436962	11.563038	10.000162	11.563200	26
35	8.441394	9.999834	8.441560	11.558440	10.000166	11.558606	25
36	8.445941	9.999831	8.446110	11.553890	10.000169	11.554059	24
37	8.450440	9.999827	8.450613	11.549387	10.000173	11.549560	23
38	8.454893	9.999823	8.455070	11.544930	10.000176	11.545107	22
39	8.459301	9.999820	8.459481	11.540519	10.000180	11.540699	21
40	8.463665	9.999816	8.463849	11.536151	10.000184	11.536335	20
41	8.467985	9.999812	8.468172	11.531827	10.000187	11.532015	19
42	8.472263	9.999809	8.472454	11.527546	10.000191	11.527737	18
43	8.476498	9.999805	8.476693	11.523307	10.000195	11.523502	17
44	8.480693	9.999801	8.480892	11.519108	10.000199	11.519307	16
45	8.484848	9.999797	8.485050	11.514949	10.000203	11.515152	15
46	8.488963	9.999793	8.489170	11.510830	10.000206	11.511037	14
47	8.493040	9.999790	8.493250	11.506750	10.000210	11.506960	13
48	8.497078	9.999786	8.497293	11.502707	10.000214	11.502922	12
49	8.501080	9.999782	8.501298	11.498702	10.000218	11.498920	11
50	8.505045	9.999778	8.505267	11.494733	10.000222	11.494955	10
51	8.508974	9.999774	8.509200	11.490800	10.000226	11.491026	9
52	8.512867	9.999769	8.513098	11.486902	10.000230	11.487133	8
53	8.516726	9.999765	8.516961	11.483039	10.000235	11.483274	7
54	8.520551	9.999761	8.520790	11.479210	10.000239	11.479449	6
55	8.524343	9.999757	8.524586	11.475414	10.000243	11.475657	5
56	8.528102	9.999753	8.528349	11.471651	10.000247	11.471898	4
57	8.531828	9.999748	8.532080	11.467920	10.000252	11.468172	3
58	8.535523	9.999744	8.535779	11.464221	10.000256	11.464477	2
59	8.539186	9.999740	8.539447	11.460553	10.000260	11.460814	1
60	8.542819	9.999735	8.543084	11.456916	10.000265	11.457181	0
		Sine		Tangent		Secant	Minutes

88 Degrees.

2 *Degrees.*

Minutes	Sine		Tangent		Secant		
0	8.542819	9.999735	8.543084	11.456916	10.000265	11.457181	60
1	8.546422	9.999731	8.546691	11.453309	10.000269	11.453578	59
2	8.549995	9.999726	8.550268	11.449732	10.000273	11.450005	58
3	8.553539	9.999722	8.553817	11.446183	10.000278	11.446461	57
4	8.557054	9.999717	8.557336	11.442664	10.000283	11.442946	56
5	8.560540	9.999713	8.560828	11.439172	10 000287	11.439460	55
6	8.563999	9.999708	8.564291	11.435709	10.000292	11.436001	54
7	8 567431	9.999704	8.567727	11.432272	10.000296	11.432569	53
8	8.570836	9.999699	8.571137	11.428863	10.000301	11.429164	52
9	8.574214	9.999694	8.574520	11.425480	10.000306	11.425786	51
10	8.577566	9.999689	8.577877	11.422123	10.000311	11.422434	50
11	8.580892	9.999685	8.581208	11.418792	10.000315	11.419108	49
12	8.584193	9.999680	8.584514	11.415486	10.000320	11.415807	48
13	8.587469	9.999675	8.587794	11.412206	10.000325	11.412531	47
14	8.590721	9.999670	8.591051	11.408949	10.000330	11.409279	46
15	8.593948	9.999665	8.594283	11.405717	10.000335	11.406052	45
16	8.597152	9.999660	8.597492	11.402508	10.000340	11.402848	44
17	8.600332	9.999655	8.600677	11.399323	10.000345	11.399668	43
18	8.603489	9.999650	8.603839	11.396161	10.000350	11.396511	42
19	8.606623	9.999645	8.606978	11.393022	10.000355	11.393377	41
20	8.609734	9.999640	8.610094	11.389906	10.000360	11.390266	40
21	8.612823	9.999635	8.613189	11.386811	10.000365	11.387176	39
22	8.615891	9.999629	8.616262	11.383738	10.000371	11.384109	38
23	8.618937	9.999624	8.619313	11.380687	10.000376	11.381063	37
24	8.621962	9.999619	8.622343	11.377657	10.000381	11.378038	36
25	8.624965	9.999614	8.625352	11.374648	10.000386	11.375035	35
26	8.627948	9.999608	8.628340	11.371660	10.000392	11.372052	34
27	8.630911	9.999603	8.631308	11.368692	10.000397	11.369089	33
28	8.633854	9.999597	8.634256	11.365744	10.000403	11.366146	32
29	8.636776	9.999592	8.637184	11.362816	10.000408	11.363224	31
30	8.639680	9.999586	8.640093	11.359907	10.000413	11.360320	30
		Sine		Tangent		Secant	Minutes

87 *Degrees.*

2 *Degrees*

Minutes	Sine		Tangent		Secant		
30	8.639680	9.999586	8.640093	11.359907	10.000413	11.360320	30
31	8.642563	9.999581	8.642982	11.357017	10.000419	11.357437	29
32	8.645428	9.999575	8.645853	11.354147	10.000425	11.354572	28
33	8.648274	9.999570	8.648704	11.351296	10.000430	11.351726	27
34	8.651102	9.999564	8.651537	11.348462	10.000436	11.348898	26
35	8.653911	9.999558	8.654352	11.345648	10.000442	11.346069	25
36	8.656702	9.999553	8.657149	11.342851	10.000447	11.343298	24
37	8.659475	9.999547	8.659928	11.340072	10.000453	11.340525	23
38	8.662230	9.999541	8.662689	11.337311	10.000459	11.337770	22
39	8.664968	9.999535	8.665433	11.334567	10.000465	11.335032	21
40	8.667689	9.999529	8.668160	11.331840	10.000470	11.332311	20
41	8.670393	9.999524	8.670870	11.329130	10.000476	11.329607	19
42	8.673080	9.999518	8.673563	11.326437	10.000482	11.326920	18
43	8.675751	9.999512	8.676239	11.323761	10.000488	11.324249	17
44	8.678405	9.999506	8.678900	11.321100	10.000494	11.321595	16
45	8.681043	9.999500	8.681544	11.318456	10.000500	11.318957	15
46	8.683665	9.999493	8.684172	11.315828	10.000506	11.316335	14
47	8.686272	9.999487	8.686784	11.313216	10.000513	11.312728	13
48	8.688863	9.999481	8.689381	11.310619	10.000519	11.311137	12
49	8.691438	9.999475	8.691963	11.308037	10.000525	1.308562	11
50	8.693998	9.999469	8.694529	11.305471	10.000531	11.306002	10
51	8.696543	9.999462	8.697081	11.302919	10.000537	11.303457	9
52	8.699073	9.999456	8.699617	11.300383	10.000544	11.300927	8
53	8.701589	9.999450	8.702139	11.297861	10.000550	11.298411	7
54	8.704090	9.999443	8.704646	11.295353	10.000556	11.295910	6
55	8.706577	9.999437	8.707139	11.292861	10.000563	11.293423	5
56	8.709049	9.999431	8.709618	11.290382	10.000569	11.290951	4
57	8.711507	9.999424	8.712083	11.287917	10.000576	11.288493	3
58	8.713952	9.999418	8.714534	11.285466	10.000582	11.286048	2
59	8.716383	9.999411	8.716972	11.283028	10.000589	11.283617	1
60	8.718800	9.999404	8.719396	11.280604	10.000596	11.281200	0
		Sine		Tangent		Secant	Minutes

87 *Degrees*

3 Degrees

Minutes	Sine		Tangent		Secant		
0	8.718800	9.999404	8.719396	11.280604	10.00 596	11.281200	60
1	8.721204	9.999398	8.721806	11.278194	10.000602	11.278796	59
2	8.723595	9.999391	8.724203	11.275796	10.000509	11.276405	58
3	8.725972	9.999384	8.726588	11.273412	10.000616	11.274028	57
4	8.728337	9.999378	8.728959	11.271041	10.000622	11.271663	56
5	8.730688	9.999371	8.731317	11.268683	10.000629	11.269312	55
6	8.733027	9.999364	8.733663	11.266337	10.000636	11.266973	54
7	8.735353	9.999357	8.735996	11.264004	10.000643	11.264646	53
8	8.737667	9.999350	8.738317	11.261683	10.000650	11.262332	52
9	8.739969	9.999343	8.740620	11.259374	10.000657	11.260031	51
10	8.742259	9.999336	8.742922	11.257078	10.000664	11.257741	50
11	8.744536	9.999329	8.745207	11.254793	10.000671	11.255464	49
12	8.746801	9.999322	8.747479	11.252521	10.000678	11.253198	48
13	8.749055	9.999315	8.749740	11.250260	10.000685	11.250945	47
14	8.751297	9.999308	8.751989	11.248011	10.000692	11.248703	46
15	8.753528	9.999301	8.754227	11.245773	10.000699	11.246472	45
16	8.755747	9.999294	8.756453	11.243547	10.000706	11.244253	44
17	8.757955	9.999286	8.758658	11.241332	10.000714	11.242045	43
18	8.760151	9.999279	8.760872	11.239128	10.000721	11.239849	42
19	8.762337	9.999272	8.763065	11.236935	10.000728	11.237663	41
20	8.764511	9.999265	8.765246	11.234754	10.000735	11.235489	40
21	8.766675	9.999257	8.767417	11.232582	10.000743	11.233325	39
22	8.768827	9.999250	8.769578	11.230422	10.000750	11.231173	38
23	8.770970	9.999242	8.771727	11.228273	10.000758	11.229030	37
24	8.773101	9.999235	8.773866	11.226134	10.000765	11.226899	36
25	8.775223	9.999227	8.775995	11.224005	10.000773	11.224777	35
26	8.777333	9.999220	8.778114	11.221886	10.000780	11.222667	34
27	8.779434	9.999212	8.780222	11.219778	10.000788	11.220500	33
28	8.781524	9.999205	8.782320	11.217680	10.000795	11.218476	32
29	8.783605	9.999197	8.784408	11.215592	10.000803	11.216395	31
30	8.785675	9.999189	8.786486	11.213514	10.000811	11.214325	30
		Sine		Tangent		Secant	Minutes

86 Degrees.

3 Degrees

Minutes	Sine		Tangent		Secant		
30	8.785675	9.999189	8.786486	11.213514	10.000811	11.214325	30
31	8.787736	9.999182	8.788554	11.211446	10.000819	11.212264	29
32	8.789787	9.999174	8.790613	11.209387	10.000826	11.210213	28
33	8.791828	9.999166	8.792662	11.207338	10.000834	11.208172	27
34	8.793859	9.999158	8.794701	11.205299	10.000842	11.206141	26
35	8.795881	9.999150	8.796731	11.203269	10.000850	11.204119	25
36	8.797894	9.999142	8.798752	11.201248	10.000858	11.202106	24
37	8.799897	9.999134	8.800763	11.199237	10.000866	11.200102	23
38	8.801891	9.999126	8.802765	11.197235	10.000874	11.198108	22
39	8.803876	9.999118	8.804758	11.195242	10.000882	11.196124	21
40	8.805852	9.999110	8.806742	11.193258	10.000890	11.194148	20
41	8.807819	9.999102	8.808717	11.191283	10.000898	11.192181	19
42	8.809777	9.999094	8.810683	11.189317	10.000906	11.190222	18
43	8.811726	9.999086	8.812641	11.187359	10.000914	11.188274	17
44	8.813667	9.999077	8.814589	11.185411	10.000923	11.186333	16
45	8.815598	9.999069	8.816529	11.183471	10.000931	11.184401	15
46	8.817522	9.999061	8.818461	11.181539	10.000939	11.182478	14
47	8.819436	9.999052	8.820384	11.179616	10.000948	11.180564	13
48	8.821342	9.999044	8.822298	11.177702	10.000956	11.178657	12
49	8.823240	9.999036	8.824205	11.175795	10.000984	11.176760	11
50	8.825130	9.999027	8.826103	11.173897	10.000973	11.174870	10
51	8.827011	9.999019	8.827992	11.172008	10.000981	11.172989	9
52	8.828884	9.999010	8.829874	11.170126	10.000990	11.171116	8
53	8.830749	9.999002	8.831748	11.168252	10.000998	11.169250	7
54	8.832607	9.998993	8.833613	11.166387	10.001007	11.167393	6
55	8.834456	9.998984	8.835471	11.164529	10.001016	11.165544	5
56	8.836297	9.998976	8.837321	11.162679	10.001024	11.163702	4
57	8.838130	9.998967	8.839163	11.160837	10.001033	11.161870	3
58	8.839956	9.998958	8.840998	11.159002	10.001042	11.160044	2
59	8.841774	9.998950	8.842824	11.157175	10.001050	11.158226	1
60	8.843584	9.998941	8.844644	11.155356	10.001059	11.156416	0
		Sine		Tangent		Secant	Minutes

86 Degrees

4 *Degrees*

Minutes	Sine		Tangent		Secant		
0	8.843584	9.998941	8.844644	11.155356	10.001059	11.156415	60
1	8.845387	9.998932	8.846455	11.153545	10.001068	11.154613	59
2	8.847183	9.998923	8.848260	11.151740	10.001077	11.152817	58
3	8.848971	9.998914	8.850057	11.149943	10.001086	11.151029	57
4	8.850751	9.998905	8.851846	11.148154	10.001095	11.149249	56
5	8.852524	9.998896	8.853628	11.146372	10.001104	11.147475	55
6	8.854290	9.998887	8.855403	11.144597	10.001113	11.145709	54
7	8.856049	9.998878	8.857171	11.142829	10.001122	11.143951	53
8	8.857801	9.998869	8.858932	11.141068	10.001131	11.142199	52
9	8.859546	9.998860	8.860686	11.139314	10.001140	11.140454	51
10	8.861283	9.998851	8.862433	11.137567	10.001149	11.138717	50
11	8.863014	9.998841	8.864172	11.135827	10.001159	11.136986	49
12	8.864738	9.998832	8.865905	11.134095	10.001168	11.135262	48
13	8.866454	9.998823	8.867632	11.132368	10.001177	11.133545	47
14	8.868165	9.998813	8.869351	11.130649	10.001186	11.131835	46
15	8.869868	9.998804	8.871064	11.128936	10.001196	11.130132	45
16	8.871565	9.998795	8.872770	11.127230	10.001205	11.128435	44
17	8.873255	9.998785	8.874465	11.125531	10.901215	11.126745	42
18	8.874938	9.998776	8.876162	11.123838	10.001224	11.125062	43
19	8.876615	9.998766	8.877849	11.122151	10.001234	11.123385	41
20	8,878285	9.998757	8.879529	11.120471	10.001243	11.121715	40
21	8.879949	9.998747	8.881202	11.118798	10.001253	11.120051	39
22	8.881607	9.998737	8.882869	11.117131	10.001262	11.118393	38
23	8.883258	9.998728	8.884530	11.115470	10.001272	11.116742	37
24	8.884903	9.998718	8.886185	11.113815	10.001282	11.115097	36
25	8.886542	9.998708	8.887833	11.112167	10.001292	11.113458	35
26	8.888174	9.998699	8.889476	11.110524	10.001301	11.111826	34
27	8.889801	9.998689	8.891112	11,108888	10.001311	11.110199	33
28	8.891421	9.998679	8.892742	11.107258	10.001321	11.108579	32
29	8.893035	9.998669	8,894366	11.105634	10.001331	11.106965	31
30	8.894643	9.098659	8.895984	11.104016	10.001341	11.105357	30
		Sine		Tangent		Secant	Minutes

85 *Degrees.*

4 Degrees

Minutes	Sine		Tangent		Secant		
30	8.894643	9.998659	8.895984	11.104016	10.001341	11.105357	30
31	8.896245	9.998649	8.897596	11.102404	10.001351	11.103754	29
32	8.897842	9.998639	8.899203	11.100797	10.001361	11.102758	28
33	8.899432	9.998629	8.900803	11.099197	10.001371	11.100568	27
34	8.901017	9.998619	8.902398	11.097602	10.001381	11.098983	26
35	8.902595	9.998609	8.903987	11.096013	10.001391	11.097404	25
36	8.904168	9.998599	8.905570	11.094430	10.001401	11.095832	24
37	8.905736	9.998588	8.907147	11.092853	10.001412	11.094264	23
38	8.907297	9.998578	8.908719	11.091281	10.001422	11.092702	22
39	8.908853	9.998568	8.910285	11.089715	10.001432	11.091146	21
40	8.910404	9.998558	8.911846	11.088154	10.001442	11.089596	20
41	8.911949	9.998547	8.913401	11.086599	10.001452	11.088051	19
42	8.913488	9.998537	8.914951	11.085049	10.001463	11.086512	18
43	8.915022	9.998527	8.916465	11.083505	10.001473	11.084978	17
44	8.996550	9.998516	8.918034	11.081966	10.001484	11.083450	16
45	8.918073	9.998506	8.919567	11.080432	10.001494	11.081927	15
46	8.919591	9.998495	8.921096	11.078904	10.001505	11.080409	14
47	8.921103	9.998485	8.922619	11.077381	10.001515	11.078897	13
48	8.922610	9.998474	8.924136	11.075864	10.001526	11.077389	12
49	8.924112	9.998464	8.925649	11.074351	10.001536	11.075888	11
50	8.925609	9.998453	8.927156	11.072844	10.001547	11.074391	10
51	8.927100	9.998442	8.928658	11.071342	10.001558	11.072900	9
52	8.928587	9.998431	8.920155	11.069845	10.001569	11.071413	8
53	8.930068	9.998421	8.931647	11.068353	10.001579	11.069932	7
54	8.931544	9.998410	8.933134	11.066865	10.001590	11.068456	6
55	8.933015	9.998399	8.934616	11.065384	10.001601	11.066985	5
56	8.934481	9.998388	8.936093	11.063907	10.001612	11.065519	4
57	8.935942	9.998377	8.937565	11.062435	10.001623	11.064058	3
58	8.937398	9.998366	8.939032	11.060968	10.001634	11.062602	2
59	8.938850	9.998355	8.940494	11.059506	10.001645	11.061150	1
60	8.940296	9.998344	8.941952	11.058048	10.001656	11.059704	0
		Sine		Tangent		Secant	Minutes

85 Degrees.

5 Degrees

	Sine		Tangent		Secant		Minutes
0	8.940296	9.998344	8.941952	11.058048	10.001656	11.059704	0
1	8.941738	9.998333	8.943404	11.056596	10.001667	11.058262	59
2	8.943174	9.998322	8.944852	11.055148	10.001678	11.056826	58
3	8.944606	9.998311	8.946295	11.053705	10.001689	11.055394	57
4	8.946033	9.998300	8.947734	11.052266	10.001700	11.053966	56
5	8.947456	9.998288	8.949168	11.050832	10.001711	11.052544	55
6	8.948874	9.998277	8.950597	11.049403	10.001723	11.051126	54
7	8.950287	9.998266	8.952021	11.047979	10.001734	11.049713	53
8	8.951696	9.998255	8.953441	11.046559	10.001745	11.048304	52
9	8.953100	9.998243	8.954856	11.045144	10.001757	11.046900	51
10	8.954499	9.998232	8.956267	11.043733	10.001768	11.045501	50
11	8.955894	9.998220	8.957673	11.042327	10.001780	11.044106	49
12	8.957284	9.998209	8.959075	11.040925	10.001791	11.042716	48
13	8.958670	9.998197	8.960473	11.039527	10.001803	11.041330	47
14	8.960052	9.998186	8.961866	11.038134	10.001814	11.039948	46
15	8.961429	9.998174	8.963254	11.036746	10.001826	11.038571	45
16	8.962801	9.998163	8.964639	11.035361	10.001837	11.037199	44
17	8.964170	9.998151	8.966019	11.033981	10.001849	11.035830	43
18	8.965534	9.998139	8.967394	11.032606	10.001861	11.034466	42
19	8.966893	9.998127	8.968766	11.031234	10.001872	11.033107	41
20	8.968249	9.998116	8.970133	11.029867	10.001884	11.031751	40
21	8.969600	9.998104	8.971496	11.028504	10.001896	11.030400	39
22	8.970947	9.998092	8.972855	11.027145	10.001908	11.029053	38
23	8.972289	9.998080	8.974209	11.025791	10.001920	11.027710	37
24	8.973628	9.998068	8.975560	11.024440	10.001932	11.026372	36
25	8.974962	9.998056	8.976906	11.023094	10.001944	11.025038	35
26	8.976293	9.998044	8.978248	11.021752	10.001956	11.023707	34
27	8.977619	9.998032	8.979586	11.020414	10.001968	11.022381	33
28	8.978941	9.998020	8.980921	11.019079	10.001980	11.021059	32
26	8.980259	9.998008	8.982251	11.017749	10.001992	11.019741	31
30	8.981573	9.997996	8.983577	11.016423	10.002004	11.018427	30
Minutes		Sine		Tangent		Secant	

84 Degrees.

5 *Degrees.*

Minutes	Sine		Tangent		Secant		
30	8.981573	9.997996	8.983577	11.016423	10.002004	11.018427	30
31	8.982883	9.997984	8.984899	11.015101	10.002016	11.017117	29
32	8.984189	9.997972	8.986217	11.013783	10.002028	11.015811	28
33	8.985491	9.997959	8.987532	11.012468	10.002041	11.014509	27
34	8.986789	9.997947	8.988842	11.011158	10.002053	11.013211	26
35	8.988083	9.997935	8.990149	11.009851	10.002065	11.011917	25
36	8.989374	9.997922	8.991451	11.008549	10.002078	11.010626	24
37	8.990660	9.997910	8.992750	11.007250	10.002090	11.009340	23
38	8.991943	9.997897	8.994045	11.005955	10.002102	11.008057	22
39	8.993222	9.997885	8.995337	11.004663	10.002115	11.006778	21
40	8.994497	9.997872	8.996624	11.003376	10.002127	11.005503	20
41	8.995768	9.997869	8.997908	11.002092	10.002141	11.004232	19
42	8.997036	9.997847	8.999188	11.000812	10.002153	11.002964	18
43	8.998299	9.997835	9.000465	10.999535	10.002165	11.001701	17
44	8.999559	9.997822	9.001737	10.998262	10.002178	11.000440	16
45	9.000816	9.997809	9.003007	10.996993	10.002191	10.999184	15
46	9.002069	9.997797	9.004272	10.995728	10.002203	10.997931	14
47	9.003318	9.997784	9.005534	10.994466	10.002216	10.996682	13
48	9.004563	9.997771	9.006792	10.993208	10.002229	10.995437	12
49	9.005805	9.997758	9.008047	10.991953	10.002242	10.994195	11
50	9.007044	9.997745	9.009298	10.990702	10.002255	10.992956	10
51	9.008278	9.997732	9.010546	10.989454	10.002266	10.991722	9
52	9.009510	9.997719	9.011790	10.988210	10.002281	10.990490	8
53	9.010737	9.997706	9.013031	10.986969	10.002294	10.989263	7
54	9.011962	9.997693	9.014268	10.985732	10.002307	10.988038	6
55	9.013182	9.997680	9.015502	10.984498	10.002320	10.986818	5
56	9.014400	9.997667	9.016732	10.983267	10.002333	10.985600	4
57	9.015613	9.997654	9.017959	10.982041	10.002346	10.984386	3
58	9.016824	9.997641	9.019183	10.980817	10.002359	10.983176	2
59	9.018031	9.997628	9.020403	10.979597	10.002372	10.981969	1
60	9.019235	9.997614	9.021620	10.978380	10.002386	10.980765	0
		Sine		Tangent		Secant	Minutes

84 *Degrees.*

6 Degrees

Minutes	Sine		Tangent		Secant		
0	9.019235	9.997614	9.021620	10.978380	10.002386	10.980765	60
1	9.020435	9.997601	9.022834	10.977166	10.002399	10.979565	59
2	9.021632	9.997588	9.024044	10.975956	10.002412	10.978368	58
3	9.022825	9.997574	9.025251	10.974749	10.002426	10.977175	57
4	9.024016	9.997561	9.026455	10.973545	10.002439	10.975984	56
5	9.025203	9.997547	9.027655	10.972345	10.002453	10.974797	55
6	9.026386	9.997534	9.028852	10.971148	10.002466	10.973614	54
7	9.027567	9.997521	9.030046	10.969954	10.002479	10.972433	53
8	9.028744	9.997507	9.031237	10.968763	10.002493	10.971256	52
9	9.029918	9.997493	9.032425	10.967575	10.002507	10.970082	51
10	9.031089	9.997480	9.033609	10.966391	10.002520	10.968911	50
11	9.032257	9.997466	9.034791	10.965209	10.002534	10.967743	49
12	9.033421	9.997452	9.035969	10.964031	10.002548	10.966579	48
13	9.034582	9.997439	9.037144	10.962856	10.002561	10.965418	47
14	9.035741	9.997425	9.038316	10.961684	10.002575	10.964259	46
15	9.036896	9.997411	9.039485	10.960515	10.002589	10.963104	45
16	9.038048	9.997397	9.040651	10.959349	10.002603	10.961952	44
17	9.039197	9.997383	9.041813	10.958187	10.002617	10.960803	43
18	9.040342	9.997369	9.042973	10.957027	10.002631	10.959658	42
19	9.041485	9.997355	9.044130	10.955870	10.002645	10.958515	41
20	9.042625	9.997341	9.045284	10.954716	10.002659	10.957375	40
21	9.043762	9.997327	9.046434	10.953566	10.002673	10.956238	39
22	9.044895	9.997313	9.047582	10.952418	10.002687	10.955105	38
23	9.046026	9.997299	9.048727	10.951273	10.002701	10.953974	37
24	9.047154	9.997285	9.049869	10.950131	10.002715	10.952846	36
25	9.048279	9.997271	9.051008	10.948992	10.002729	10.951721	35
26	9.049400	9.997257	9.052144	10.947856	10.002743	10.950600	34
27	9.050519	9.997242	9.053277	10.946723	10.002758	10.949481	33
28	9.051635	9.997228	9.054407	10.945593	10.002772	10.948365	32
29	9.052748	9.997214	9.055535	10.944465	10.002786	10.947252	31
30	9.053859	9.997199	9.056659	10.943340	10.002801	10.946141	30
		Sine		Tangent		Secant	Minutes

83 Degrees

6 *Degrees.*

Minutes	Sine		Tangent		Secant		
30	9.053859	9.997199	9.056659	10.943341	10.002801	10.94614	30
31	9.054066	9.997185	9.057781	10.942219	10.002815	10.945034	29
32	9.056071	9.997170	9.058900	10.941100	10.002830	10.943929	28
33	9.057172	9.997156	9.060016	10.939984	10.002844	10.942828	27
34	9.058271	9.997141	9.061130	10.938870	10.002859	10.941729	26
35	9.059367	9.997127	9.062240	10.937760	10.002873	10.940633	25
36	9.06046	9.997112	9.063348	10.936652	10.002888	10.939540	24
37	9.061551	9.997098	9.064453	10.935547	10.002902	10.938449	23
38	9.062639	9.997083	9.065556	10.934444	10.002917	10.937361	22
39	9.063723	9.997068	9.066655	10.933345	10.002932	10.936277	21
40	9.064806	9.997053	9.067752	10.932248	10.002947	10.935194	20
41	9.065885	9.997039	9.068846	10.931154	10.002961	10.934115	19
42	9.066962	9.997024	9.069938	10.930062	10.002976	10.933038	18
43	9.068036	9.997009	9.071027	10.928973	10.002991	10.931964	17
44	9.069107	9.996994	9.072113	10.927887	10.003006	10.930893	16
45	9.070176	9.996979	9.073197	10.926803	10.003021	10.929824	15
46	9.071242	9.996964	9.074278	10.925722	10.003036	10.928758	14
47	9.072305	9.996949	9.075356	10.924644	10.003051	10.927694	13
48	9.073366	9.996934	9.076432	10.923568	10.003066	10.926634	12
49	9.074424	9.996919	9.077505	10.922495	10.003081	10.925576	11
50	9.075480	9.996904	9.078576	10.921424	10.003096	10.924520	10
51	9.076533	9.996889	9.079644	10.920356	10.003111	10.923467	9
52	9.077583	9.996874	9.080710	10.919290	10.003126	10.922417	8
53	9.078631	9.996858	9.081773	10.918227	10.003142	10.921369	7
54	9.079676	9.996843	9.082833	10.917167	10.003157	10.920324	6
55	9.080719	9.996828	9.083891	10.916109	10.003172	10.919281	5
56	9.081759	9.996812	9.084947	10.915053	10.003188	10.918241	4
57	9.082797	9.996797	9.086000	10.914000	10.003203	10.917203	3
58	9.083832	9.996782	9.087050	10.912950	10.003218	10.916168	2
59	9.084864	9.996766	9.088098	10.911902	10.003234	10.915136	1
60	9.085894	9.996751	9.089144	10.910856	10.003249	10.914106	0
		Sine		Tangent		Secant	Minutes

83 *Degrees*

7 Degrees

Minutes	Sine		Tangent		Secant		
0	9.085894	9.996751	9.089144	10.910856	10.003249	10.914105	60
1	9.086922	9.996735	9.090187	10.909813	10.003265	10.913078	59
2	9.087947	9.996720	9.091228	10.908772	10.003280	10.912053	58
3	9.088970	9.996704	9.092266	10.907734	10.003296	10.911030	57
4	9.089990	9.996688	9.093302	10.906698	10.003312	10.910010	56
5	9.091008	9.996673	9.094335	10.905665	10.003327	10.908992	55
6	9.092024	9.996657	9.095367	10.904633	10.003343	10.907976	54
7	9.093037	9.996641	9.096395	10.903605	10.003359	10.906963	53
8	9.094047	9.996625	9.097422	10.902578	10.003375	10.905953	52
9	9.095056	9.996610	9.098446	10.901554	10.003390	10.904944	51
10	9.096061	9.996594	9.099468	10.900532	10.003406	10.903938	50
11	9.097065	9.996578	9.100487	10.899513	10.003422	10.902935	49
12	9.098066	9.996562	9.101504	10.898496	10.003438	10.901934	48
13	9.099065	9.996546	9.102519	10.897481	10.003454	10.900935	47
14	9.100062	9.996530	9.103532	10.896468	10.003470	10.899938	46
15	9.101056	9.996514	9.104542	10.895458	10.003486	10.898944	45
16	9.102048	9.996498	9.105550	10.894450	10.003502	10.897952	44
17	9.103037	9.996482	9.106550	10.893444	10.003518	10.896963	43
18	9.104025	9.996465	9.107559	10.892441	10.003535	10.895975	42
19	9.105010	9.996449	9.108560	10.891440	10.003551	10.894990	41
20	9.105992	9.99643	9.109559	10.890441	10.003567	10.894008	40
21	9.106973	9.996417	9.110556	10.889444	10.003583	10.893027	39
22	9.107951	9.996400	9.111551	10.888449	10.003600	10.892049	38
23	9.108927	9.996384	9.112543	10.887457	10.003616	10.891073	37
24	9.109901	9.996368	9.113533	10.886467	10.003632	10.890099	36
25	9.110873	9.996351	9.114521	10.885479	10.003649	10.889127	35
26	9.111842	9.996335	9.115507	10.884493	10.003665	10.888158	34
27	9.112809	9.996388	9.116491	10.883509	10.003682	10.887191	33
28	9.113774	9.996302	9.117472	10.882528	10.003698	10.886226	32
29	9.114737	9.996285	9.118452	10.881548	10.003715	10.885263	31
30	9.115698	9.996269	9.119429	10.880571	10.003731	10.884302	30
		Sine		Tangent		Secant	Minutes

82 Degrees

7 Degrees.

Minutes	Sine		Tangent		Secant		
30	9.115698	9.996269	9.119429	10.880571	10.003731	10.884302	30
31	9.116656	9.996252	9.120404	10.879596	10.003748	10.883344	29
32	9.117612	9.996235	9.121377	10.878623	10.003765	10.882388	28
33	9.118567	9.996218	9.122348	10.877652	10.003782	10.881433	27
34	9.119519	9.996202	9.123317	10.876683	10.003798	10.880481	26
35	9.120469	9.996185	9.124284	10.875716	10.003815	10.879531	25
36	9.121417	9.996168	9.125249	10.874751	10.003832	10.878583	24
37	9.122362	9.996151	9.126211	10.873789	10.003849	10.877638	23
38	9.123306	9.996134	9.127172	10.872828	10.003866	10.876694	22
39	9.124248	9.996117	9.128130	10.871870	10.003883	10.875752	21
40	9.125187	9.996100	9.129087	10.870913	10.003900	10.874813	20
41	9.126125	9.996083	9.130041	10.869959	10.003917	10.873875	19
42	9.127060	9.996066	9.130994	10.869006	10.003934	10.872940	18
43	9.127993	9.996049	9.131944	10.868056	10.003951	10.872007	17
44	9.128925	9.996032	9.132893	10.867107	10.003968	10.871075	16
45	9.129854	9.996015	9.133839	10,866161	10.003985	10.870146	15
46	9.130781	9.995998	9.134783	10.865217	10.004002	10.869219	14
47	9.131706	9.995980	9.135726	10.864274	10.004020	10.868294	13
48	9.132630	9.995963	9.136666	10.863334	10.004037	10.867370	12
49	9.133551	9.995946	9.137605	10.862395	10.004054	10.866449	11
50	9.134470	9.995928	9.138542	10.861458	10.004072	10.865530	10
51	9.135387	9.995911	9.139476	10.860524	10.004089	10.864613	9
52	9.136303	9.995894	9.140409	10.859591	10.004106	10.863697	8
53	9.137216	9.995876	9.141340	10.858660	10.004124	10.862784	7
54	9.138127	9.995859	9.142269	10.857731	10.004141	10.86187	6
55	9.139037	9.995841	9.143196	10.856804	10.004159	10.860963	5
56	9.139944	9.995823	9.144121	10.855879	10.004177	10.860056	4
57	9.140850	9.995806	9.145044	10.854956	10.004194	10.85915	3
58	9.141754	9.995788	9.145965	10.854035	10.004212	10.858246	2
59	9.142655	9.995770	9.146885	10.853115	10.004230	10.857345	1
60	9.143555	9.995753	9.147802	10.852198	10.004247	10.856445	0
		Sine		Tangent		Secant	Minutes

82 Degrees.

8 *Degrees*

Minutes	Sine		Tangent		Secant		
0	9.143555	9.995753	9.147802	10.852198	10.004247	10.856445	60
1	9.144453	9.995735	9.148718	10.851282	10.004265	10.855547	59
2	9.145349	9.995717	9.149632	10.850368	10.004283	10.854651	58
3	9.146243	9.995699	9.150544	10.849456	10.004301	10.853757	57
4	9.147136	9.995681	9.151454	10.848546	10.004319	10.852864	56
5	9.148026	9.995663	9.152363	10.847637	10.004337	10.851974	55
6	9.148915	9.995646	9.153269	10.846731	10.004354	10.851085	54
7	9.149801	9.995628	9.154174	10.845826	10.004372	10.850199	53
8	9.150686	9.995609	9.155077	10.844923	10.004391	10.849314	52
9	9.151569	9.995591	9.155978	10.844022	10.004409	10.848431	51
10	9.152451	9.995573	9.156877	10.843123	10.004427	10.847549	50
11	9.153330	9.995555	9.157775	10.842225	10.004445	10.846670	49
12	9.154208	9.995537	9.158671	10.841329	10.004463	10.845792	48
13	9.155083	9.995519	9.159565	10.840435	10.004481	10.844917	47
14	9.155957	9.995500	9.160457	10.839543	10.004500	10.844043	46
15	9.156830	9.995482	9.161347	10.838653	10.004518	10.843170	45
16	9.157700	9.995464	9.162236	10.837764	10.004536	10.842300	44
17	9.158569	9.995445	9.163123	10.836877	10.004555	10.841431	43
18	9.159435	9.995427	9.164008	10.835992	10.004573	10.840565	42
19	9.160300	9.995409	9.164892	10.835108	10.004591	10.839700	41
20	9.161164	9.995390	9.165774	10.834226	10.004610	10.838836	40
21	9.162025	9.995372	9.166654	10.833346	10.004628	10.837975	39
22	9.162885	9.995353	9.167532	10.832468	10.004647	10.837115	38
23	9.16374	9.995334	9.168409	10.831591	10.004666	10.836257	37
24	9.164600	9.995316	9.169284	10.830716	10.004684	10.835400	36
25	9.165454	9.995297	9.170157	10.829843	10.004703	10.834546	35
26	9.166307	9.995278	9.171029	10.828971	10.004722	10.833693	34
27	9.167159	9.995260	9.171899	10.828101	10.004740	10.832841	33
28	9.168008	9.995241	9.172767	10.827233	10.004759	10.831992	32
29	9.168856	9.995222	9.173634	10.826366	10.004778	10.831144	31
30	9.169702	9.995203	9.174499	10.825501	10.004797	10.830298	30
		Sine		Tangent		Secant	Minutes

81 *Degrees*

8 *Degrees.*

Minutes	Sine		Tangent		Secant		
30	9.169702	9.995203	9.174499	10.825501	10.004797	10.830298	30
31	9.170546	9.995184	9.175362	10.824638	10.004816	10.829454	29
32	9.171389	9.995165	9.176224	10.823776	10.004835	10.828611	28
33	9.172230	9.995146	9.177084	10.822916	10.004854	10.827770	27
34	9.173070	9.995127	9.177942	10.822058	10.004873	10.826930	26
35	9.173908	9.995108	9.178799	10.821201	10.004892	10.826092	25
36	9.174744	9.995089	9.179655	10.820345	10.004911	10.825256	24
37	9.175578	9.995070	9.180508	10.819492	10.004930	10.824422	23
38	9.176411	9.995051	9.181360	10.818640	10.004949	10.823589	22
39	9.177242	9.995032	9.182211	10.817789	10.004968	10.822758	21
40	9.178072	9.995013	9.183059	10.816941	10.004987	10.821928	20
41	9.178900	9.994993	9.183907	10.816093	10.005007	10.821100	19
42	9.179726	9.994974	9.184752	10.815248	10.005026	10.820274	18
43	9.180551	9.994955	9.185597	10.814403	10.005045	10.819449	17
44	9.181374	9.994935	9.186439	10.813561	10.005065	10.818626	16
45	9.182196	9.994916	9.187280	10,812720	10.005084	10.817804	15
46	9.183016	9.994896	9.188120	10.811880	10.005104	10.816984	14
47	9.183834	9.994877	9.188957	10.811043	10.005123	10.816166	13
48	9.184651	9.994857	9.189794	10.810206	10.005143	10.815349	12
49	9.185466	9.994838	9.190629	10.809371	10.005162	10.814534	11
50	9.186280	9.994818	9.191162	10.808538	10.005182	10.813720	10
51	9.187092	9.994798	9.192294	19.807706	10.005202	10.812908	9
52	9.187903	9.994779	9.193124	10.806876	10.005221	10.812097	8
53	9.188712	9.994759	9.193953	10.806047	10.005241	10.811288	7
54	9.189519	9.994739	9.194780	10.805220	10.005261	10.810481	6
55	9.190325	9.994719	9.195606	10.804394	10.005281	10.809675	5
56	9.191130	9.994700	9.196430	10.803570	10.005300	10.808870	4
57	9.191933	9.994680	9.197253	10.802747	10.005320	10.808067	3
58	9.192734	9.994660	9.198074	10.801926	10.005340	10.807266	2
59	9.193534	9.994640	9.198894	10.801106	10.005360	10.806466	1
60	9.194332	9.994620	9.199712	10.800288	10.005380	10.805668	0
		Sine		Tangent		Secant	Minutes

81 *Degrees.*

9 *Degrees*

Minutes	Sine		Tangent		Secant		
0	9.194332	9.994620	9.199712	10.800288	10.005280	10.805668	60
1	9.195129	9.994600	9.200529	10.799471	10.005400	10.804871	59
2	9.195925	9.994580	9.201345	10.798655	10.005420	10.804075	58
3	9.196719	9.994560	9.202159	10.797841	10.005440	10.803281	57
4	9.197511	9.994540	9.202971	10.797029	10.005460	10.802489	56
5	9.198302	9.994519	9.203782	10.796218	10.005481	10.801698	55
6	9.199091	9.994499	9.204592	10.795408	10.005501	10.800909	54
7	9.199879	9.994479	9.205400	10.794600	10.005521	10.800121	53
8	9.200666	9.994459	9.206207	10.793793	10.005541	10.799334	52
9	9.201451	9.994438	9.207013	10.792987	10.005562	10.798549	51
10	9.202234	9.994418	9.207816	10.792183	10.005582	10.797766	50
11	9.203017	9.994397	9.208619	10.791381	10.005603	10.796983	49
12	9.203797	9.994377	9.209420	10.790580	10.005623	10.796203	48
13	9.204577	9.994357	9.210220	10.789780	10.005643	10.795423	47
14	9.205354	9.994336	9.211018	10.788982	10.005664	10.794646	46
15	9.206131	9.994316	9.211815	10.788185	10.005684	10.793869	45
16	9.206906	9.994295	9.212611	10.787389	10.005705	10.793094	44
17	9.207679	9.994274	9.213405	10.786595	10.005726	10.792321	43
18	9.208452	9.994254	9.214198	10.785802	10.005746	10.791548	42
19	9.209222	9.994233	9.214989	10.785011	10.005767	10.790778	41
20	9.209992	9.994212	9.215779	10.784221	10.005788	10.790008	40
21	9.210760	9.994191	9.216568	10.783432	10.005809	10.789240	39
22	9.211526	9.994171	9.217356	10.782644	10.005829	10.788474	38
23	9.212291	9.994150	9.218142	10.781858	10.005850	10.787709	37
24	9.213055	9.994129	9.218926	10.781074	10.005871	10.786945	36
25	9.213818	9.994108	9.219710	10.780290	10.005892	10.786182	35
26	9.214579	9.994087	9.220492	10.779508	10.005913	10.785421	34
27	9.215338	9.994066	9.221272	10.778728	10.005934	10.784662	33
28	9.216097	9.994045	9.222052	10.777948	10.005955	10.783903	32
29	9.216854	9.994024	9.222830	10.777170	10.005976	10.783146	31
30	9.217609	9.994003	9.223606	10.776394	10.005997	10.782391	30
		Sine		Tangent		Secant	Minutes

80 *Degrees*

9 *Degrees.*

Minutes	Sine		Tangent		Secant		
30	9.217609	9.994003	9.223606	10.776394	10.005997	10.782391	30
31	9.218363	9.993981	9.224382	10.775618	10.006019	10.781637	29
32	9.219116	9.993960	9.225156	10.774844	10.006040	10.780884	28
33	9.219868	9.993939	9.225929	10.774071	10.006061	10.780132	27
34	9.220618	9.993918	9.226700	10.773300	10.006082	10.779382	26
35	9.221367	9.993896	9.227471	10.772529	10.006103	10.778633	25
36	9.222115	9.993875	9.228239	10.771760	10.006125	10.777885	24
37	9.222861	9.993854	9.229007	10.770993	10.006146	10.777139	23
38	9.223606	9.993832	9.229773	10.770226	10.006168	10.776394	22
39	9.224349	9.993811	9.230539	10 769461	10.006189	10.775650	21
40	9.225092	9.993789	9.231302	10.768698	10.006211	10.774908	20
41	9.225833	9.993768	9.232065	10.767935	10.006233	10.774165	19
42	9.226573	9.993746	9.232826	10.767174	10.006254	10.773427	18
43	9.227311	9.993725	9.233586	10.766414	10.006275	10.772689	17
44	9.228048	9.993703	9.234345	10.765655	10.006297	10.771952	16
45	9.228784	9.993681	9.235103	10.764897	10.006319	10.771216	15
46	9.229518	9.993660	9.235859	10.764141	10.006340	10.770481	14
47	9.230252	9.993638	9.236614	10.763386	10.006362	10.769748	13
48	9.230984	9.993616	9.237368	10.762632	10.006384	10.769016	12
49	9.231714	9.993594	9.238120	10.761880	10.006406	10.768285	11
50	9.232444	9.993572	9.238872	10.761128	10.006428	10.767556	10
51	9.233172	9.993550	9.239622	10.760378	10.006454	10.766828	9
52	9.233899	9.993528	9.240371	10.759629	10.006472	10.766101	8
53	9.234625	9.993506	9.241118	10.758882	10.006493	10.765375	7
54	9.235349	9.993484	9.241865	10.758135	10.006516	10.764651	6
55	9.236073	9.993462	9.242610	10.757390	10.006538	10.763927	5
56	9.236795	9.993440	9.243354	10.756646	10.006560	10.763205	4
57	9.237515	9.993418	9.244097	10.755903	10.006582	10.762485	3
58	9.238235	9.993396	9.244839	10.755161	10.006604	10.761765	2
59	9.238953	9.993374	9.245579	10.754421	10.006626	10.761047	1
60	9.239070	9.993352	9.246319	10.753681	10.006648	10.760330	0
		Sine		Tangent		Secant	Minutes

80 *Degrees*

10 *Degrees.*

Minutes	Sine		Tangent		Secant		
0	9.239670	9.993351	9.246319	10.753681	10.006649	10.760330	60
1	9.240386	9.993329	9.247057	10.752943	10.006671	10.759614	59
2	9.241101	9.993307	9.247794	10.752206	10.006693	10.758899	58
3	9.241814	9.993284	9.248530	10.751470	10.006716	10.758186	57
4	9.242526	9.993262	9.249264	10.750736	10.006738	10.757474	56
5	9.243237	9.993240	9.249998	10.750002	10.006760	10.756763	55
6	9.243947	9.993217	9.250730	10.749270	10.006783	10.756053	54
7	9.244656	9.993195	9.251461	10.748539	10.006805	10.755344	53
8	9.245363	9.993172	9.252191	10.747809	10.006828	10.754637	52
9	9.246069	9.993149	9.252920	10.747080	10.006851	10.753931	51
10	9.246775	9.993127	9.253648	10.746352	10.006873	10.753225	50
11	9,247478	9.993104	9.254374	10.745626	10.006896	10.752522	49
12	9-248181	9.993081	9.255100	10.74490	10.006919	10.751819	48
13	9.248883	9.993059	9.255824	10.744176	10.006941	10.7511 7	47
14	9.249583	9.993036	9.256547	10.743453	10.006964	10.750417	46
15	9.250282	9.993013	9.257269	10.742731	10.006987	10.749718	45
16	9.250980	9.992990	9.257990	10.74201	10.007010	10.749020	44
17	9.251677	9.992967	9.258710	10.74129	10.007033	10.748323	43
18	9.252373	9.992944	9.259428	10.740572	10.007056	10.747627	42
19	9.253067	9.992921	9.260146	10.739854	10.007079	10.746933	41
20	9.253761	9.992898	9.260862	10.739138	10.007102	10.746239	40
21	9.254453	9.992875	9.261578	10.738422	10.007125	10.745547	39
22	9-255144	9.992852	9.262292	10.737708	10.007148	10.744856	38
23	9.255834	9.992829	9.263005	10.736995	10.007171	10.744166	37
24	9,256523	9.992806	9.263717	10.736283	10.007194	10.743477	36
25	9.257211	9.99278	9.264428	10.735572	10.007217	10.742789	35
26	9.257898	9.992759	9.265138	10.734862	10.007241	10.742.02	34
27	9.258583	9.992736	9.265847	10.734153	10.007264	10.741417	33
28	9.259268	9.992713	9.266555	10.733445	10.007287	10.740732	32
29	9.259951	9.992689	9.267261	10.732739	10.007311	10.740049	31
30	9.260633	9.992666	9.267967	10.732033	10.007334	10.739367	30
		Sine		Tangent		Secant	Minutes

79 *Degrees.*

10 *Degrees.*

Minutes	Sine		Tangent		Secant		
30	9.260633	9.992666	9.267967	10.732033	10.007334	10.739367	30
31	9.261314	9.992643	9.268671	10.731329	10.007357	10.738686	29
32	9.261994	9.992619	9.269375	10.730625	10.007381	10.738006	28
33	9.262673	9.992596	9.270077	10.729923	10.007404	10.737327	27
34	9.263351	9.992572	9.270779	10.729221	10.007428	10.736649	26
35	9.264027	9.992549	9.271479	10.728521	10.007451	10.735973	25
36	9.264703	9.992525	9.272178	10.727822	10.007475	10.735297	24
37	9.265377	9.992501	9.272876	10.727124	10.007499	10.734623	23
38	9.266051	9.992478	9.273573	10.726427	10.007522	10.733949	22
39	9.266723	9.992454	9.274269	10.72573	10.007546	10.733277	21
40	9.267395	9.992430	9.274964	10.725036	10.007570	10.732605	20
41	9.268065	9.992406	9.275658	10.724342	10.007594	10.731935	19
42	9.268734	9.992382	9.276351	10.723649	10.007618	10.731266	18
43	9.269402	9.992358	9.277043	10.722957	10.007642	10.730598	17
44	9.270069	9.992335	9.277734	10.722266	10.007665	10.729931	16
45	9.270735	9.992311	9.27842	10.721576	10.007689	10.729265	15
46	9.271400	9.992287	9.279113	10.720887	10.007713	10.728600	14
47	9.272063	9.992263	9.279801	10.720199	10.007737	10.727937	13
48	9.272726	9.992238	9.280488	10.719512	10.007762	10.727274	12
49	9.273388	9.992214	9.281174	10.718826	10.007786	10.726612	11
50	9.274049	9.992190	9.281858	10.718142	10.007810	10.725951	10
51	9.274708	9.992166	9.282542	10.717458	10.007834	10.725292	9
52	9.275367	9.992142	9.283225	10.716775	10.007858	10.724633	8
53	9.276024	9.992117	9.283907	10.716093	10.007883	10.723976	7
54	9.216681	9.992093	9.284588	10.715412	10.007907	10.723319	6
55	9.277337	9.992069	9.285268	10.714732	10.007931	10.722663	5
56	9.277991	9.992044	9.285947	10.714053	10.007956	10.722009	4
57	9.278644	9.992020	9.286624	10.713376	10.007980	10.721356	3
58	9.279297	9.991996	9.287301	10.712699	10.008004	10.720703	2
59	9.279948	9.991971	9.287977	10.712023	10.008029	10.720052	1
60	9.280599	9.991947	9.288652	10.711348	10.008053	10.719401	0
		Sine		Tangent		Secant	Minutes

79 *Degrees.*

11 *Degrees.*

Minutes	Sine		Tangent		Secant		
0	9.280599	9.991947	9.288652	10.711348	10.008053	10.719401	60
1	9.281248	9.991922	9.289326	10.710674	10.008078	10.718752	59
2	9.281897	9.991897	9.289999	10.710001	10.008103	10.718103	58
3	9.282544	9.991873	9.290671	10.709329	10.008127	10.717456	57
4	9.283190	9.991848	9.291342	10.708658	10.008152	10.716810	56
5	9.283836	9.991823	9.292013	10.707987	10.008177	10.716164	55
6	9.284480	9.991799	9.292682	10.707318	10.008201	10.715520	54
7	9.285124	9.991774	9.293350	10.706650	10.008226	10.714876	53
8	9.285766	9.991749	9.294017	10.705983	10.008251	10.714234	52
9	9.286408	9.991724	9.294684	10.705316	10.008276	10.713592	51
10	9.287048	9.991699	9.295349	10.704651	10.008301	10.712952	50
11	9,287687	9.991674	9.296013	10.703987	10.008326	10.712313	49
12	9.288326	9.991649	9.296677	10.703323	10.008351	10.711674	48
13	9.288964	9.991624	9.297339	10.702661	10.008376	10.711036	47
14	9.289600	9.991599	9.298001	10.701999	10.008401	10.710400	46
15	9.290236	9.991574	9.298662	10.701338	10.008426	10.709764	45
16	9.290870	9.991549	9.299322	10.700678	10.008451	10.709130	44
17	9.291504	9.991524	9.299980	10.700020	10.008476	10.708496	43
18	9.292137	9.991498	9.300638	10.699362	10.008502	10.707863	42
19	9.292768	9.991473	9.301295	10.698705	10.008527	10.707232	41
20	9.293399	9.991448	9.301951	10.698049	10.008552	10.706601	40
21	9.294029	9.991422	9.302607	10.697393	10.008577	10:705971	39
22	9-294658	9.991397	9.303261	10.696739	10.008603	10.705342	38
23	9.295286	9.991372	9.303914	10.696086	10.008628	10.704714	37
24	9,295913	9.991346	9.304567	10.695433	10.008654	10.704087	36
25	9.296539	9.991321	9.305218	10.694782	10.008679	10.703461	35
26	9.297164	9.991295	9.305869	10.694131	10.008705	10.702836	34
27	9.297788	9.991270	9.306519	10.693481	10.008730	10.702212	33
28	9.298412	9.991244	9.307167	10.692833	10.008756	10.701588	32
29	9.299034	9.991218	9.307815	10.692185	10.008782	10.700966	31
30	9.299655	9.991193	9.308463	10.691537	10.008807	10.700345	30
		Sine		Tangent		Secant	Minutes

78 *Degrees.*

11 *Degrees.*

Minutes	Sine		Tangent		Secant		
30	9.299655	9.991193	9.308463	10.691537	10.008807	10.700345	30
31	9.300276	9.991167	9.309105	10.690891	10.008833	10.699724	29
32	9.300895	9.991141	9.309754	10.690246	10.008859	10.699105	28
33	9.301514	9.991115	9.310398	10.689602	10.008885	10.698486	27
34	9.302132	9.991090	9.311042	10.688958	10.008910	10.697868	26
35	9.302748	9.991064	9.311685	10.688315	10.008936	10.697251	25
36	9.303364	9.991038	9.312327	10.687673	10.008962	10.696636	24
37	9.303979	9.991012	9.312967	10.687033	10.008988	10.696021	23
38	9.304593	9.990986	9.313608	10.686392	10.009014	10.695407	22
39	9.305207	9.990960	9.314247	10.685753	10.009040	10.694793	21
40	9.305819	9.990934	9.314885	10.685115	10.009066	10.694181	20
41	9.306430	9.990908	9.315523	10.684477	10.009092	10.693570	19
42	9.307041	9.990881	9.316159	10.683841	10.009118	10.692959	18
43	9.307650	9.990855	9.316795	10.683205	10.009145	10.692350	17
44	9.308259	9.990829	9.317430	10.682570	10.009171	10.691741	16
45	9.308867	9.990803	9.318064	10.681936	10.009197	10.691133	15
46	9.309474	9.990777	9.318697	10.681303	10.009223	10.690520	14
47	9.310080	9.990750	9.319329	10.680671	10.009250	10.689920	13
48	9.310685	9.990724	9.319961	10.680039	10.009276	10.689315	12
49	9.311289	9.990697	9.320592	10.679408	10.009303	10.688711	11
50	9.311893	9.990671	9.321222	10.678778	10.009329	10.688107	10
51	9.312495	9.990644	9.321851	10.678149	10.009356	10.687505	9
52	9.313097	9.990618	9.322479	10.677521	10.009382	10.686903	8
53	9.313698	9.990591	9.323106	10.676894	10.009409	10.686302	7
54	9.314297	9.990565	9.323733	10.676267	10.009435	10.685702	6
55	9.314896	9.990538	9.324358	10.675642	10.009462	10.685104	5
56	9.315495	9.990511	9.324983	10.675017	10.009489	10.684505	4
57	9.316092	9.990485	9.325607	10.674393	10.009515	10.683908	2
58	9.316688	9.990458	9.326230	10.673770	10.009542	10.683312	2
59	9.317284	9.990431	9.326853	10.673147	10.009569	10.682716	1
60	9.317879	9.990404	9.327474	10.672526	10.009596	10.682121	0
		Sine		Tangent		Secant	Minutes

78 *Degrees.*

12 Degrees

Minutes	Sine		Tangent		Secant		
0	9.317879	9.990404	9.327474	10.672526	10.009596	10.68212	60
1	9.318473	9.990377	9.328095	10.671905	10.009623	10.681527	59
2	9.319066	9.990351	9.328715	10.671285	10.009649	10.680934	58
3	9.319658	9.990324	9.329334	10.670666	10.009676	10.680342	57
4	9.320249	9.990297	9.329953	10.670047	10.009703	10.679751	56
5	9.320840	9.990270	9.330570	10.669430	10.009730	10.679160	55
6	9.321430	9.990243	9.331187	10.668813	10.009757	10.678570	54
7	9.322019	9.990215	9.331803	10.668197	10.009785	10.677981	53
8	9.322607	9.990188	9.332418	10.667582	10.009812	10.677393	52
9	9.323194	9.990161	9.333033	10.666967	10.009839	10.676806	51
10	9.323780	9.990134	9.333646	10.666354	10.009866	10.676220	50
11	9.324366	9.990107	9.334259	10.665741	10.009893	10.675634	49
12	9.324950	9.990079	9.334871	10.665129	10.009921	10.675049	48
13	9.325534	9.990052	9.335482	10.664518	10.009948	10.674466	47
14	9.326117	9.990025	9.336093	10.663907	10.009975	10.673883	46
15	9.326700	9.989997	9.336702	10.663298	10.010003	10.673300	45
16	9.327281	9.989970	9.337311	10.662689	10.010030	10.672719	44
17	9.327862	9.989942	9.337919	10.662081	10.010058	10.672138	43
18	9.328442	9.989915	9.338527	10.661473	10.010085	10.671558	42
19	9.329021	9.989887	9.339133	10.660867	10.010113	10.670979	41
20	9.329599	9.989860	9.339739	10.660261	10.010140	10.670401	40
21	9.330176	9.989832	9.340344	10.659656	10.010168	10.669824	39
22	9.330753	9.989804	9.340948	10.659052	10.010196	10.669247	38
23	9.331328	9.989777	9.341552	10.658448	10.010223	10.668672	37
24	9.331903	9.989749	9.342155	10.657845	10.010251	10.668097	36
25	9.332478	9.989721	9.342757	10.657243	10.010279	10.667522	35
26	9.333051	9.989693	9.343358	10.656642	10.010307	10.666949	34
27	9.333624	9.989665	9.343958	10.656042	10.010335	10.666376	33
28	9.334195	9.989637	9.344558	10.655442	10.010363	10.665805	32
29	9.334766	9.989609	9.345157	10.654843	10.010391	10.665234	31
30	9.335337	9.989581	9.345755	10.654245	10.010419	10.664663	30
		Sine		Tangent		Secant	Minutes

77 Degrees

12 Degrees.

Minutes	Sine		Tangent		Secant		
30	9.335337	9.989581	9.345755	10.654245	10.010419	10.664663	30
31	9.335906	9.989553	9.346353	10.653647	10.010447	10.664094	29
32	9.336475	9.989525	9.346949	10.653051	10.010475	10.663525	28
33	9.337043	9.989497	9.347545	10.652455	10.010503	10.662957	27
34	9.337610	9.989469	9.348041	10.651859	10.010531	10.662390	26
35	9.338176	9.989441	9.348735	10.651265	10.010559	10.661824	25
36	9.338742	9.989413	9.349329	10.650671	10.010587	10.661258	24
37	9.339306	9.989384	9.349922	10.650078	10.010616	10.660694	23
38	9.339871	9.989356	9.350514	10.649486	10.010644	10.660129	22
39	9.340434	9.989328	9.351106	10.648894	10.010672	10.659566	21
40	9.340996	9.989299	9.351697	10.648303	10.010701	10.659004	20
41	9.341558	9.989271	9.352287	10.647713	10.010729	10.658442	19
42	9.342119	9.989243	9.352876	10.647124	10.010757	10.657881	18
43	9.342679	9.989214	9.353465	10.646535	10.010786	10.657321	17
44	9.343239	9.989186	9.354053	10.645947	10.010814	10.656761	16
45	9.343797	9.989157	9.354640	10.645360	10.010843	10.656203	15
46	9.344355	9.989128	9.355227	10.644773	10.010872	10.655645	14
47	9.344912	9.989100	9.355813	10.644187	10.010900	10.655088	13
48	9.345469	9.989071	9.356398	10.643602	10.010929	10.654531	12
49	9.346024	9.989042	9.356982	10.643018	10.010958	10.653976	11
50	9.346579	9.989014	9.357566	10.642434	10.010186	10.653421	10
51	9.347134	9.988985	9.358149	10.641851	10.011015	10.652866	9
52	9.347687	9.988956	9.358731	10.641269	10.011044	10.652313	8
53	9.348240	9.988927	9.359313	10.640687	10.011073	10.651760	7
54	9.348792	9.988898	9.359893	10.640107	10.011102	10.650208	6
55	9.349343	9.988869	9.360474	10.639526	10.011131	10.650657	5
56	9.349893	9.988840	9.361053	10.638947	10.011160	10.650107	4
57	9.350443	9.988811	9.361632	10.638368	10.011189	10.649557	3
58	9.350992	9.988782	9.362210	10.637790	10.011218	10.649008	2
59	9.351540	9.988753	9.362787	10.637213	10.011247	10.648460	1
60	9.352088	9.988724	9.363364	10.636636	10.011276	10.647912	0
		Sine		Tangent		Secant	Minutes

77 Degrees.

13 *Degrees*

Minutes	Sine		Tangent		Secant		
0	9.352088	9.988724	9.363364	10.636636	10.011276	10.647912	60
1	9.352635	9.988695	9.363940	10.636060	10.011305	10.647365	59
2	9.353181	9.988665	9.364515	10.635484	10.011334	10.646819	58
3	9.353726	9.988636	9.365090	10.634910	10.011364	10.646274	57
4	9.354271	9.988607	9.365664	10.634336	10.011393	10.645729	56
5	9.354815	9.988578	9.366237	10.633763	10.011422	10.645185	55
6	9.355358	9.988548	9.366810	10.633190	10.011452	10.644642	54
7	9.355901	9.988519	9.367382	10.632618	10.011481	10.644099	53
8	9.356443	9.988489	9.367953	10.632047	10.011511	10.643557	52
9	9.356984	9.988460	9.368524	10.631476	10.011540	10.643016	51
10	9.357524	9.988430	9.369094	10.630906	10.011570	10.642476	50
11	9.358064	9.988401	9.369663	10.630337	10.011599	10.641936	49
12	9.358603	9.988371	9.370231	10.629768	10.011629	10.641397	48
13	9.359141	9.988341	9.370799	10.629201	10.011658	10.640859	47
4	9.359678	9.988312	9.371367	10.628633	10.011688	10.640321	46
15	9.360215	9.988282	9.371933	10.628067	10.011718	10.639785	45
16	9.360751	9.988252	9.372499	10.627501	10.011748	10.639249	44
17	9.361287	9.988222	9.373064	10.626935	10.011777	10.638713	43
18	9.361822	9.988193	9.373629	10.626371	10.011807	10.638178	42
19	9.362356	9.988163	9.374193	10.625807	10.011837	10.637644	41
20	9.362889	9.988133	9.374756	10.625244	10.011867	10.637111	40
21	9.363422	9.988103	9.375319	10.624681	10.011897	10.636578	39
22	9.363954	9.988073	9.375881	10.624119	10.011927	10.636046	38
23	9.364485	9.988043	9.376442	10.623558	10.011957	10.635515	37
4	9.365016	9.988013	9.377003	10.622997	10.011987	10.634984	36
25	9.365546	9.987983	9.377563	10.622437	10.012 17	10.634454	35
26	9.366075	9.987952	9.378122	10.621877	10.012047	10.633925	34
27	9.366604	9.987922	9.378681	10.621319	10.012078	10.633396	33
28	9.367131	9.987892	9.379239	10.620761	10.012108	10.632868	32
29	9.367659	9.987862	9.379797	10.620203	10.012138	10.632341	31
30	9.368185	9.987831	9.380354	10.619640	10.012168	10.631815	30
		Sine		Tangent		Secant	Minutes

76 *Degrees*

13 *Degrees.*

Minutes	Sine		Tangent		Secant		
30	9.368185	9.987831	9.380354	10.619646	10.012169	10.631815	30
31	9.368711	9.987801	9.380910	10.619090	10.012199	10.631289	29
32	9.369236	9.987771	9.381465	10.618535	10.012229	10.630764	28
33	9.369761	9.987740	9.382020	10.617980	10.012260	10.630239	27
34	9.370285	9.987710	9.382575	10.617425	10.012290	10.629715	26
35	9.370808	9.987679	9.383129	10.616871	10.012321	10.629192	25
36	9.371330	9.987649	9.383682	10.616318	10.012351	10.628670	24
37	9.371852	9.987618	9.384234	10.615766	10.012382	10.628148	23
38	9.372373	9.987588	9.384786	10.615214	10.012412	10.627627	22
39	9.372894	9.987557	9.385337	10.614663	10.012443	10.627106	21
40	9.373414	9.987526	9.385888	10.614112	10.012474	10.626586	20
41	9.373933	9.987495	9.386438	10.613562	10.012505	10.626067	19
42	9.374452	9.987465	9.386987	10.613013	10.012535	10.625548	18
43	9.374970	9.987434	9.387536	10.612464	10.012566	10.625030	17
44	9.375487	9.987403	9.388084	10.611916	10.012597	10.624513	16
45	9.376003	9.987372	9.388631	10.611369	10.012628	10.623997	15
46	9.376519	9.987341	9.389178	10.610822	10.012659	10.623481	14
47	9.377035	9.987310	9.389724	10.610276	10.012690	10.622965	13
48	9.377549	9.987279	9.390270	10.609730	10.012721	10.622451	12
49	9.378063	9.987248	9.390815	10.609185	10.012752	10.621937	11
50	9.378577	9.987217	9.391359	10.608641	10.012783	10.621423	10
51	9.379089	9.987186	9.391903	10.608097	10.012814	10.620911	9
52	9.379601	9.987155	9.392447	10.607553	10.012845	10.620399	8
53	9.380113	9.987124	9.392989	10.607011	10.012876	10.619887	7
54	9.380624	9.987092	9.393531	10.606469	10.012908	10.619376	6
55	9.381134	9.987061	9.394073	10.605927	10.012939	10.618866	5
56	9.381643	9.987030	9.394614	10.605386	10.012970	10.618357	4
57	9.382152	9.986998	9.395154	10.604846	10.013002	10.617848	3
58	9.382660	9.986967	9.395693	10.604307	10.013033	10.617340	2
59	9.383168	9.986936	9.396233	10.603767	10.013064	10.616832	1
60	9.383675	9.986904	9.396771	10.603229	10.013096	10.616325	0
		Sine		Tangent		Secant	Minutes

76 *Degrees.*

14 *Degrees.*

Minutes	Sine		Tangent		Secant		
0	9.383675	9.986904	9.396771	10.603229	10.013096	10.616325	60
1	9.384181	9.986873	9.397309	10.602691	10.013127	10.615819	59
2	9.384687	9.986841	9.397846	10.602154	10.013159	10.615313	58
3	9.385192	9.986809	9.398383	10.601617	10.013191	10.614808	57
4	9.385697	9.986978	9.398919	10.601081	10.013222	10.614303	56
5	9.386201	9.986746	9.399455	10.600545	10.013254	10.613799	55
6	9.386704	9.986714	9.399990	10.600010	10.013286	10.613296	54
7	9.387207	9.986683	9.400524	10.599476	10.013317	10.612793	53
8	9.387709	9.986651	9.401058	10.598942	10.013349	10.612291	52
9	9.388210	9.986619	9.401591	10.598409	10.013381	10.611790	51
10	9.388711	9.986587	9.402124	10.597876	10.013413	10.611289	50
11	9,389211	9.986555	9.402656	10.597344	10.013445	10.610789	49
12	9-389711	9.986523	9.403187	10.596813	10.013477	10.610289	48
13	9.390210	9.986491	9.403718	10.596282	10.013509	10.609790	47
14	9.390708	9.986459	9.404249	10.595751	10.013541	10.609292	46
15	9.391206	9.986427	9.404778	10.595222	10.013573	10.608794	45
16	9.391703	9.986395	9.405308	10.594692	10.013605	10.608297	44
17	9.392199	9.986363	9.405836	10.594164	10.013637	10.607801	43
18	9.392695	9.986331	9.406364	10.593636	10.013669	10.607305	42
19	9.393190	9.986299	9.406892	10.593108	10.013701	10.606810	41
20	9.393685	9.986266	9.407419	10.592581	10.013734	10.606315	40
21	9.394179	9.986234	9.407945	10.592055	10.013766	10:605821	39
22	9-394673	9.986202	9.408471	10.591529	10.013798	10.605327	38
23	9.395166	9.986169	9.408996	10.591003	10.013831	10.604834	37
24	9,395658	9.986137	9.409521	10.590479	10.013863	10.604342	36
25	9.396150	9.986104	9.410045	10.589955	10.013896	10.603850	35
26	9.396641	9.986072	9.410569	10.589431	10.013928	10.603359	34
27	9.397132	9.986039	9.411092	10.588908	10.013961	10.602868	33
28	9.397621	9.986007	9.411615	10.588385	10.013993	10.602379	32
29	9.398111	9.985974	9.412137	10.587863	10.014026	10.601889	31
30	9.398600	9.985942	9.412658	10.587342	10.014058	10.601400	30
		Sine		Tangent		Secant	Minutes

75 *Degrees.*

14 *Degrees.*

Minutes	Sine		Tangent		Secant		
30	9.398600	9.985942	9.412658	10.587342	10.014058	10.601400	30
31	9.399088	9.985909	9.413179	10.586821	10.014091	10.600912	29
32	9.399575	9.985876	9.413699	10.586301	10.014124	10.600425	28
33	9.400062	9.985843	9.414219	10.585781	10.014157	10.599938	27
34	9.400549	9.985811	9.414738	10.585262	10.014189	10.599451	26
35	9.401035	9.985778	9.415257	10.584743	10.014222	10.598965	25
36	9.401520	9.985745	9.415775	10.584225	10 014255	10.598480	24
37	9 402005	9.985712	9.416293	10.583707	10.014288	10.597995	23
38	9.402489	9.985679	9.416810	10.583190	10.014321	10.597511	22
39	9.402972	9.985646	9.417326	10.582674	10.014354	10.597028	21
40	9.403455	9.985613	9.417842	10.582158	10.014387	10.596549	20
41	9.403938	9.985580	9.418358	10.581642	10.014420	10.596062	19
42	9.404420	9.985547	9.418873	10.581127	10.014453	10.595580	18
43	9.404901	9.985513	9.419387	10.580613	10.014487	10.595099	17
44	9.405382	9.985480	9.419901	10.580099	10.014520	10.594618	16
45	9.405862	9.985447	9.420415	10.579585	10.014553	10.594138	15
46	9.406341	9.985414	9.420927	10.579073	10.014586	10.593659	14
47	9.406820	9.985380	9.421440	10.578560	10.014620	10.593180	13
48	9.407299	9.985347	9.421951	10.578049	10.014653	10.592701	12
49	9.407777	9.985314	9.422463	10.577537	10.014686	10.592223	11
50	9.408254	9.985280	9.422973	10.577027	10.014720	10.591746	10
51	9.408731	9.985247	9.423484	10.576516	10.014753	10.591269	9
52	9.409207	9.985213	9.423993	10.576007	10.014787	10.590793	8
53	9.409682	9.985180	9.424503	10.575497	10.014820	10.590318	7
54	9.410157	9.985146	9.425011	10.574989	10.014854	10.589843	6
55	9.410632	9.985112	9.425519	10.574481	10.014888	10.589368	5
56	9.411106	9.985079	9.426027	10.573973	10.014921	10.588894	4
57	9.411579	9.985045	9.426534	10.573466	10.014955	10.588421	3
58	9.412052	9.985011	9.427041	10.572959	0.014989	10.587948	2
59	9.412524	9.984978	9.427547	10.572453	10.015022	10.587476	1
60	9.412996	9.984944	9.428052	10.571948	10.015056	10.587004	0
		Sine		Tangent		Secant	Minutes

75 *Degrees.*

15 *Degrees.*

Minutes	Sine		Tangent		Secant		
0	9.412995	9.984944	9.428052	10.571948	10.015056	10.587004	60
1	9.413467	9.984910	9.428557	10.571443	10.015090	10.586533	59
2	9.413938	9.984876	9.429062	10.570938	10.015124	10.586062	58
3	9.414408	9.984842	9.429566	10.570434	10.015158	10.585592	57
4	9.414878	9.984808	9.430070	10.569930	10.015192	10.585122	56
5	9.415347	9.984774	9.430573	10.569427	10.015226	10.584653	55
6	9.415815	9.984740	9.431075	10.568925	10.015260	10.584185	54
7	9.416283	9.984706	9.431577	10.568423	10.015294	10.583717	53
8	9.416751	9.984672	9.432079	10.567921	10.015328	10.583249	52
9	9.417217	9.984637	9.432580	10.567420	10.015363	10.582783	51
10	9.417684	9.984603	9.433080	10.566920	10.015397	10.582316	50
11	9,418149	9.984569	9.433580	10.566420	10.015431	10.581851	49
12	9-418615	9.984535	9.434080	10.565920	10.015465	10.581385	48
13	9.419079	9.984500	9.434579	10.565421	10.015500	10.580921	47
14	9.419544	9.984466	9.435078	10.564922	10.015534	10.580456	46
15	9.420007	9.984432	9.435576	10.564424	10.015568	10.579993	45
16	9.420470	9.984397	9.436073	10.563927	10.015603	10.579530	44
17	9.420933	9.984363	9.436570	10.563430	10.015637	10.579067	43
18	9.421395	9.984328	9.437067	10.562933	10.015672	10.578605	42
19	9.421857	9.984293	9.437563	10.562437	10.015707	10.578143	41
20	9.422318	9.984259	9.438059	10.561941	10.015741	10.577682	40
21	9.422778	9.984224	9.438554	10.561446	10.015776	10:577222	39
22	9-423238	9.984189	9.439048	10.560952	10.015811	10.576762	38
23	9.423697	9.984155	9.439543	10.560457	10.015845	10.576303	37
24	9,424156	9.984120	9.440036	10.559964	10.015880	10.575844	36
25	9.424615	9.984085	9.440529	10.559471	10.015915	10.575385	35
26	9.425073	9.984050	9.441022	10.558978	10.015950	10.574927	34
27	9.425530	9.984015	9.441514	10.558486	10.015985	10.574470	33
28	9.425987	9.983981	9.442006	10.557994	10.016019	10.574013	32
29	9.426443	9.983946	9.442497	10.557503	10.016054	10.573557	31
30	9.426899	9.983910	9.442988	10.557012	10.016090	10.573101	30
		Sine		Tangent		Secant	Minutes

74 *Degrees.*

15 *Degrees*

Minutes	Sine		Tangent		Secant		
30	9.426899	9.983910	9.442988	10.557012	10.016090	10.573101	30
31	9.427354	9.983875	9.443479	10.556521	10.016125	10.572646	29
32	9.427809	9.983840	9.443968	10.556032	10.016160	10.572191	28
33	9.428263	9.983805	9.444458	10.555542	10.016195	10.571737	27
34	9.428717	9.983770	9.444947	10.555053	10.016230	10.571283	26
35	9.429170	9.983735	9.445435	10.554565	10.016265	10.570830	25
36	9.429623	9.983700	9.445923	10.554077	10.016300	10.570377	24
37	9.430075	9.983664	9.446411	10.553589	10.016336	10.569925	23
38	9.430527	9.983629	9.446898	10.553102	10.016371	10.569473	22
39	9.430978	9.983594	9.447384	10.552616	10.016406	10.569022	21
40	9.431429	9.983558	9.447870	10.552130	10.016442	10.568571	20
41	9.431879	9.983523	9.448356	10.551644	10.016477	10.568121	19
42	9.432328	9.983487	9.448841	10.551159	10.016513	10.567672	18
43	9.432778	9.983452	9.449326	10.550674	10.016548	10.567222	17
44	9.433226	9.983416	9.449810	10.550190	10.016584	10.566774	16
45	9.433675	9.983380	9.450294	10.549706	10.016620	10.566325	15
46	9.434122	9.983345	9.450777	10.549223	10.016655	10.565878	14
47	9.434569	9.983309	9.451260	10.548740	10.016691	10.565431	13
48	9.435016	9.983273	9.451743	10.548257	10.016727	10.564984	12
49	9.435462	9.983238	9.452225	10.547775	10.016762	10.564538	11
50	9.435908	9.983202	9.452706	10.547294	10.016798	10.564092	10
51	9.436353	9.983166	9.453187	10.546813	10.016834	10.563647	9
52	9.436798	9.983130	9.453668	10.546332	10.016870	10.563202	8
53	9.437242	9.983094	9.454148	10.545852	10.016906	10.562758	7
54	9.437686	9.983058	9.454628	10.545372	10.016942	10.562314	6
55	9.438129	9.983022	9.455107	10.544893	10.016978	10.561871	5
56	9.438572	9.982986	9.455586	10.544414	10.017014	10.561428	4
57	9.439014	9.982950	9.456064	10.543936	10.017050	10.560986	3
58	9.439456	9.982914	9.456542	10.543458	10.017086	10.560544	2
59	9.439897	9.982878	9.457019	10.542981	10.017122	10.560103	1
60	9.440338	9.982842	9.457496	10.542504	10.017158	10.559662	0
		Sine		Tangent		Secant	Minute

74 *Degrees.*

16 *Degrees*

Minutes	Sine		Tangent		Secant		
0	9.440338	9.982842	9.457496	10.542504	10.017158	10.559662	60
1	9.440778	9.982805	9.457973	10.542027	10.017195	10.559222	59
2	9.441218	9.982769	9.458449	10.541551	10.017231	10.558782	58
3	9.441658	9.982733	9.458925	10.541075	10.017267	10.558342	57
4	9.442096	9.982696	9.459400	10.540600	10.017304	10.557904	56
5	9.442535	9.982660	9.459875	10.540125	10.017340	10.557465	55
6	9.442973	9.982624	9.460349	10.539651	10.017376	10.557027	54
7	9.443410	9.982587	9.460823	10.539177	10.017413	10.556590	53
8	9.443847	9.982551	9.461297	10.538703	10.017449	10.556153	52
9	9.444284	9.982514	9.461770	10.538230	10.017486	10.555716	51
10	9.444720	9.982477	9.462242	10.537758	10.017523	10.555280	50
11	9.445155	9.982441	9.462714	10.537286	10.017559	10.554845	49
12	9.445590	9.982404	9.463186	10.536814	10.017596	10.554410	48
13	9.446025	9.982367	9.463658	10.536342	10.017633	10.553975	47
14	9.446459	9.982331	9.464128	10.535872	10.017669	10.553541	46
15	9.446893	9.982294	9.464599	10.535401	10.017706	10.553107	45
16	9.447326	9.982257	9.465069	10.534931	10.017743	10.552674	44
17	9.447759	9.982220	9.465539	10.534461	10.017780	10.552241	43
18	9.448191	9.982183	9.466008	10.533992	10.017817	10.551809	42
19	9.448623	9.982146	9.466476	10.533524	10.017854	10.551377	41
20	9.449054	9.982109	9.466945	10.533055	10.017891	10.550946	40
21	9.449485	9.982072	9.467413	10.532587	10.017928	10.550515	39
22	9.449915	9.982035	9.467880	10.532120	10.017965	10.550085	38
23	9.450345	9.981998	9.468347	10.531653	10.018002	10.549655	37
24	9.450775	9.981961	9.468814	10.531186	10.018039	10.549225	36
25	9.451204	9.981924	9.469280	10.530720	10.018076	10.548796	35
26	9.451632	9.981886	9.469746	10.530254	10.018114	10.548368	34
27	9.452060	9.981849	9.470211	10.529789	10.018151	10.547940	33
28	9.452488	9.981812	9.470676	10.529324	10.018188	10.547512	32
29	9.452915	9.981774	9.471141	10.528859	10.018226	10.547085	31
30	9.453342	9.981737	9.471605	10.528395	10.018263	10.546658	30
		Sine		Tangent		Secant	Minutes

73 *Degrees.*

16 *Degrees*

Minutes	Sine		Tangent		Secant		
30	9.453342	9.981737	9.471605	10.528395	10.018263	10.546658	30
31	9.453768	9.981699	9.472068	10.527932	10.018301	10.546232	29
32	9.454194	9.981662	9.472532	10.527468	10.018338	10.545806	28
33	9.454619	9.981624	9.472995	10.527005	10.018375	10.545381	27
34	9.455044	9.981587	9.473457	10.526543	10.018413	10.544956	26
35	9.455469	9.981549	9.473919	10.526081	10.018451	10.544531	25
36	9.455893	9.981512	9.474381	10.525019	10.018488	10.544107	24
37	9.456316	9.981474	9.474842	10.525158	10.018526	10.543684	23
38	9.456739	9.981436	9.475303	10.524697	10.018564	10.543261	22
39	9.457162	9.981399	9.475763	10.524237	10.018601	10.542838	21
40	9.457584	9.981361	9.476223	10.523777	10.018639	10.542416	20
41	9.458006	9.981323	9.476683	10.523317	10.018677	10.541994	19
42	9.458427	9.981285	9.477142	10.522858	10.018715	10.541573	18
43	9.458848	9.981247	9.477601	10.522399	10.018753	10.541152	17
44	9.459268	9.981209	9.478059	10.521941	10.018791	10.540732	16
45	9.459688	9.981171	9.478517	10.521483	10.018829	10.540312	15
46	9.460108	9.981133	9.478975	10.521025	10.018867	10.539892	14
47	9.460527	9.981095	9.479422	10.520568	10.018905	10.539473	13
48	9.460946	9.981057	9.479889	10.520111	10.018943	10.539054	12
49	9.461364	9.981019	9.480345	10.519655	10.018981	10.538636	11
50	9.461782	9.980980	9.480801	10.519199	10.019020	10.538218	10
51	9.462199	9.980942	9.481257	10.518743	10.019058	10.537801	9
52	9.462616	9.980904	9.481712	10.518288	10.019096	10.537384	8
53	9.463032	9.980866	9.482167	10.517833	10.019134	10.536968	7
54	9.463448	9.980827	9.482621	10.517379	10.019173	10.536552	6
55	9.463864	9.980789	9.483075	10.516925	10.019211	10.536136	5
56	9.464279	9.980750	9.483529	10.516471	10.019249	10.535721	4
57	9.464694	9.980712	9.483982	10.516018	10.019288	10.535306	3
58	9.465108	9.980673	9.484435	10.515565	10.019327	10.534892	2
59	9.465522	9.980635	9.484887	10.515113	10.019365	10.534478	1
60	9.465935	9.980596	9.485339	10.514661	10.019404	10.534065	0
		Sine		Tangent		Secant	Minutes

73 *Degrees.*

17 *Degrees*

Minutes	Sine		Tangent		Secant		
0	9.465935	9.980596	9.485339	10.514661	10.019404	10.534065	60
1	9.466348	9.980558	9.485791	10.514209	10.019442	10.533652	59
2	9.466761	9.980519	9.486242	10.513758	10.019481	10.533239	58
3	9.467173	9.980480	9.486693	10.513307	10.019520	10.532827	57
4	9.467585	9.980441	9.487143	10.512857	10.019559	10.532415	56
5	9.467996	9.980403	9.487593	10.512407	10.019597	10.532004	55
6	9.468407	9.980364	9.488043	10.511957	10.019636	10.531593	54
7	9.468817	9.980325	9.488492	10.511508	10.019675	10.531183	53
8	9.469227	9.980286	9.489941	10.511059	10.019714	10.530773	52
9	9.469637	9.980247	9.489390	10.510610	10.019753	10.530363	51
10	9.470046	9.980208	9.489838	10.510162	10.019792	10.529954	50
11	9.470455	9.980169	9.490286	10.509714	10.019831	10.529545	49
12	9.470863	9.980130	9.490733	10.509267	10.019870	10.529137	48
13	9.471271	9.980091	9.491181	10.508820	10.019909	10.528729	47
14	9.471678	9.980052	9.491627	10.508373	10.019948	10.528322	46
15	9.472086	9.980012	9.492073	10.507927	10.019988	10.527914	45
16	9.472492	9.979973	9.492519	10.507481	10.020027	10.527508	44
17	9.472898	9.979934	9.492965	10.507035	10.020066	10.527102	43
18	9.473304	9.979895	9.493410	10.506590	10.020105	10.526696	42
19	9.473710	9.979855	9.493854	10.506146	10.020145	10.526290	41
20	9.474115	9.979816	9.494299	10.505701	10.020184	10.525885	40
21	9.474519	9.979776	9.494743	10.505257	10.020224	10.525481	39
22	9.474923	9.979737	9.495186	10.504814	10.020263	10.525077	38
23	9.475327	9.979697	9.495630	10.504370	10.020303	10.524673	37
24	9.475730	9.979658	9.496073	10.503927	10.020342	10.524270	36
25	9.476133	9.979618	9.496515	10.503485	10.020382	10.523867	35
26	9.476536	9.979578	9.496957	10.503043	10.020422	10.523464	34
27	9.476938	9.979539	9.497399	10.502601	10.020461	10.523062	33
28	9.477340	9.979499	9.497841	10.502159	10.020501	10.522660	32
29	9.477741	9.979459	9.498282	10.501718	10.020541	10.522259	31
30	9.478142	9.979419	9.498722	10.501278	10.020581	10.521858	30
		Sine		Tangent		Secant	Minutes

72 *Degrees.*

17 *Degrees.*

Minutes	Sine		Tangent		Secant		
30	9.478142	9.979419	9.498722	10.501278	10.020581	10.521858	30
31	9.478542	9.979380	9.499163	10.500837	10.020620	10.521458	29
32	9.478942	9.979340	9.499603	10.500397	10.020660	10.521058	28
33	9.479342	9.979300	9.500042	10.499958	10.020700	10.520658	27
34	9.479741	9.979260	9.500481	10.499519	10.020740	10.520259	26
35	9.480140	9.979220	9.500920	10.499080	10.020780	10.519860	25
36	9.480538	9.979180	9.501359	10.498641	10.020820	10.519462	24
37	9.480937	9.979140	9.501797	10.498203	10.020860	10.519063	23
38	9.481334	9.979100	9.502235	10.497765	10.020900	10.518666	22
39	9.481731	9.979059	9.502672	10.497328	10.020941	10.518269	21
40	9.482128	9.979019	9.503109	10.496891	10.020981	10.517872	20
41	9.482525	9.978979	9.503546	10.496454	10.021021	10.517475	19
42	9.482921	9.978939	9.503982	10.496018	10.021061	10.517079	18
43	9.483316	9.978898	9.504418	10.495582	10.021102	10.516684	17
44	9.483712	9.978858	9.504854	10.495146	10.021142	10.516288	16
45	9.484107	9.978817	9.505289	10.494711	10.021183	10.515893	15
46	9.484501	9.978777	9.505724	10.494276	10.021223	10.515499	14
47	9.484895	9.978736	9.506159	10.493841	10.021264	10.515105	13
48	9.485289	9.978696	9.506593	10.493407	10.021304	10.514711	12
49	9.485682	9.978655	9.507027	10.492973	10.021345	10.514318	11
50	9.486075	9.978615	9.507460	10.492540	10.021385	10.513925	10
51	9.486467	9.978574	9.507893	10.492107	10.021426	10.513533	9
52	9.486859	9.978533	9.508326	10.491674	10.021467	10.513141	8
53	9.487251	9.978493	9.508759	10.491241	10.021507	10.512749	7
54	9.487643	9.978452	9.509191	10.490809	10.021548	10.512357	6
55	9.488033	9.978411	9.509622	10.490378	10.021589	10.511967	5
56	9.488424	9.978370	9.510054	10.489946	10.021630	10.511576	4
57	9.488814	9.978329	9.510485	10.489515	10.021671	10.511186	3
58	9.489204	9.978288	9.510916	10.489084	10.021712	10.510796	2
59	9.489593	9.978247	9.511346	10.488654	10.021753	10.510407	1
60	9.489982	9.978206	9.511776	10.488224	10.021794	10.510018	0
		[Sine		Tangent		Secant	Minutes

72 *Degrees.*

18 *Degrees*

Minutes	Sine		Tangent		Secant		
0	9.489982	9.978206	9.511776	10.488224	10.021794	10.510018	60
1	9.499371	9.978165	9.512206	10.487794	10.021835	10.509629	59
2	9.490759	9.978124	9.512635	10.487365	10.021876	10.509241	58
3	9.491147	9.978083	9.513064	10.486936	10.021917	10.508853	57
4	9.491534	9.978042	9.513493	10.486507	10.021958	10.508466	56
5	9.491922	9.978001	9.513921	10.486079	10.021999	10.508078	55
6	9.492308	9.977959	9.514349	10.485651	10.022041	10.507692	54
7	9.492695	9.977918	9.514777	10.485223	10.022082	10.507305	53
8	9.493081	9.977877	9.515204	10.484796	10.022123	10.506919	52
9	9.493466	9.977835	9.515631	10.484369	10.022165	10.506534	51
10	9.493851	9.977794	9.516057	10.483942	10 022206	10.506149	50
11	9.494236	9.977752	9.516484	10.483516	10.022248	10.505764	49
12	9.494620	9.977711	9.516910	10.483090	10.022289	10.505380	48
13	9.495005	9.977669	9.517335	10.482665	10.022331	10.504995	47
14	9.495388	9.977628	9.517761	10.482239	10.022372	10.504612	46
15	9.495772	9.977586	9.518185	10.481815	10.022414	10.504228	45
16	9.496154	9.977544	9.518610	10.481390	10.022456	10.503846	44
17	9.496537	9.977503	9.519034	10.480966	10.022497	10.503463	43
18	9.496919	9.977461	9.519458	10.480542	10.022539	10.503081	42
19	9.497301	9.977419	9.519882	10.480118	10.022581	10.502699	41
20	9.497682	9.977377	9.520305	10.479695	10.022623	10.502318	40
21	9.498063	9.977335	9.520728	10.479272	10.022665	10.501937	39
22	9.498444	9.977293	9.521151	10.478849	10.022707	10.501556	38
23	9.498824	9.977251	9.521573	10 478427	10.022749	10.501176	37
24	9.499204	9.977209	9.521995	10.478005	10.022791	10.500796	36
25	9.499584	9.977167	9.522417	10.477583	10.022833	10.500416	35
26	9.499963	9.977125	9.522838	10.477162	10 022875	10.500037	34
27	9.500342	9.977083	9.523259	10.476741	10.022917	10.499658	33
28	9.500721	9.977041	9.523679	10.476321	10.022959	10.499279	32
29	9.501099	9.976999	9.524100	10.475900	10.023001	10.498901	31
30	9.501476	9.976957	9.524520	10.475480	10.023043	10.498524	30
		Sine		Tangent		Secant	Minutes

71 *Degrees*

18 *Degrees.*

Minutes	Sine		Tangent		Secant		
30	9.501476	9.976957	9.524520	10.475480	10.023043	10.498524	30
31	9.501854	9.976914	9.524939	10.475061	10.023086	10.498146	29
32	9.502231	9.976872	9.525359	10.474641	10.023128	10.497769	28
33	9.502607	9.976830	9.525778	10.474222	10.023170	10.497393	27
34	9.502984	9.976787	9.526197	10.473803	10.023213	10.497016	26
35	9.503360	9.976745	9.526615	10.473385	10.023255	10.496640	25
36	9.503735	9.976702	9.527033	10.472967	10.023298	10.496265	24
37	9.504110	9.976660	9.527451	10.472549	10.023340	10.495890	23
38	9.504485	9.976617	9.527868	10.472132	10.023383	10.495515	22
39	9.504860	9.976574	9.528285	10.471715	10.023426	10.495140	21
40	9.505234	9.976532	9.528702	10.471298	10.023468	10.494766	20
41	9.505608	9.976489	9.529119	10.470881	10.023511	10.494392	19
42	9.505981	9.976446	9.529535	10.470465	10.023554	10.493019	18
43	9.506354	9.976404	9.529950	10.470050	10.023596	10.493646	17
44	9.506727	9.976361	9.530366	10.469634	10.023639	10.493273	16
45	9.507099	9.976318	9.530781	10.469219	10.023682	10.492901	15
46	9.507471	9.976275	9.531196	10.468804	10.023725	10.492529	14
47	9.507843	9.976232	9.531611	10.468389	10.023768	10.492157	13
48	9.508214	9.976189	9.532025	10.467975	10.023811	10.491786	12
49	9.508585	9.976146	9.532439	10.467561	10.023854	10.491415	11
50	9.508956	9.976103	9.532853	10.467147	10.023897	10.491044	10
51	9.509326	9.976060	9.533266	10.466734	10.023940	10.490674	9
52	9.509696	9.976017	9.533679	10.466321	10.023983	10.490304	8
53	9.510065	9.975974	9.534092	10.465908	10.024026	10.489935	7
54	9.510434	9.975930	9.534504	10.465496	10.024070	10.489566	6
55	9.510803	9.975887	9.534916	10.465084	10.024113	10.489197	5
56	9.511172	9.975844	9.535328	10.464672	10.024156	10.488828	4
57	9.511540	9.975800	9.535739	10.464261	10.024200	10.488461	3
58	9.511907	9.975757	9.536150	10.463850	10.024243	10.488093	2
59	9.512275	9.975713	9.536561	10.463439	10.024287	10.487725	1
60	9.512642	9.975670	9.536972	10.463028	10.024330	10.487358	0
		Sine		Tangent		Secant	Minutes

71 *Degrees.*

19 *Degrees*

Minutes	Sine		Tangent		Secant		
0	9.512642	9.975670	9.536972	10.463028	10.024330	10.487358	60
1	9.513009	9.975626	9.537382	10.462618	10.024374	10.486991	59
2	9.513375	9.975583	9.537792	10.462208	10.024417	10.486625	58
3	9.513741	9.975539	9.538202	10.461798	10.024461	10.486259	57
4	9.514107	9.975496	9.538611	10.461389	10.024504	10.485893	56
5	9.514472	9.975452	9.539020	10.460980	10.024548	10.485528	55
6	9.514837	9.975408	9.539429	10.460571	10.024592	10.485163	54
7	9.515202	9.975365	9.539837	10.460163	10.024635	10.484798	53
8	9.515566	9.975321	9.540245	10.459755	10.024679	10.484434	52
9	9.515930	9.975277	9.540653	10.459347	10.024723	10.484070	51
10	9.516294	9.975233	9.541061	10.458939	10.024767	10.483706	50
11	9.516657	9.975189	9.541468	10.458532	10.024811	10.483343	49
12	9.517020	9.975145	9.541875	10.458125	10.024855	10.482980	48
13	9.517382	9.975101	9.542281	10.457719	10.024899	10.482618	47
14	9.517745	9.975057	9.542688	10.457312	10.024943	10.482255	46
15	9.518107	9.975013	9.543094	10.456906	10.024987	10.481893	45
16	9.518468	9.974969	9.543499	10.456501	10.025031	10.481532	44
17	9.518829	9.974925	9.543905	10.456095	10.025075	10.481171	43
18	9.519190	9.974880	9.544310	10.455690	10.025120	10.480810	42
19	9.519551	9.974836	9.544715	10.455285	10.025164	10.480449	41
20	9.519911	9.974792	9.545119	10.454881	10.025208	10.480089	40
21	9.520271	9.974747	9.545524	10.454476	10.025253	10.479729	39
22	9.520631	9.974703	9.545928	10.454072	10.025297	10.479369	38
23	9.520990	9.974659	9.546331	10.453669	10.025341	10.479010	37
24	9.521349	9.974614	9.546735	10.453265	10.025386	10.478651	36
25	9.521707	9.974570	9.547138	10.452862	10.025430	10.478293	35
26	9.522066	9.974525	9.547540	10.452460	10.025475	10.477934	34
27	9.522423	9.974481	9.547943	10.452057	10.025519	10.477577	33
28	9.522781	9.974436	9.548345	10.451655	10.025564	10.477219	32
29	9.523138	9.974391	9.548747	10.451253	10.025609	10.476862	31
30	9.523495	9.974347	9.549149	10.450851	10.025653	10.476505	30
		Sine		Tangent		Secant	Minutes

70 *Degrees*

19 *Degrees.*

Minutes	Sine		Tangent		Secant		
30	9.523495	9.974347	9.549149	10.450851	10.025653	10.476505	30
31	9.523852	9.974302	9.549550	10.450450	10.025698	10.476148	29
32	9.524208	9.974257	9.549951	10.450049	10.025743	10.475792	28
33	9.524564	9.974212	9.550352	10.449648	10.025788	10.475436	27
34	9.524920	9.974167	9.550752	10.449248	10.025833	10.475080	26
35	9.525275	9.974122	9.551152	10.448848	10.025878	10.474725	25
36	9.525630	9.974077	9.551552	10.448448	10.025923	10.474370	24
37	9.525984	9.974032	9.551952	10.448048	10.025968	10.474016	23
38	9.526339	9.973987	9.552351	10.447649	10.026013	10.473661	22
39	9.526693	9.973942	9.552750	10.447250	10.026058	10.473307	21
40	9.527046	9.973897	9.553149	10.446851	10.026103	10.472954	20
41	9.527400	9.973852	9.553548	10.446452	10.026148	10.472600	19
42	9.527753	9.973807	9.553946	10.446054	10.026193	10.472247	18
43	9.528105	9.973761	9.554344	10.445656	10.026239	10.471895	17
44	9.528458	9.973716	9.554741	10.445259	10.026284	10.471542	16
45	9.528810	9.973671	9.555139	10.444861	10.026329	10.471190	15
46	9.529161	9.973625	9.555536	10.444464	10.026375	10.470839	14
47	9.529513	9.973580	9.555933	10.444067	10.026420	10.470487	13
48	9.529864	9.973535	9.556329	10.443671	10.026465	10.470136	12
49	9.530215	9.973489	9.556725	10.443275	10.026511	10.469785	11
50	9.530565	9.973443	9.557121	10.442879	10.026557	10.469435	10
51	9.530915	9.973398	9.557517	10.442483	10.026602	10.469085	9
52	9.531265	9.973352	9.557912	10.442088	10.026648	10.468735	8
53	9.531614	9.973307	9.558308	10.441690	10.026693	10.468386	7
54	9.531963	9.973261	9.558702	10.441298	10.026739	10.468037	6
55	9.532312	9.973215	9.559097	10.440903	10.026785	10.467688	5
56	9.532661	9.973169	9.559491	10.440509	10.026831	10.467339	4
57	9.533009	9.973124	9.559885	10.440115	10.026876	10.466991	3
58	9.533357	9.973078	9.560279	10.439721	10.026922	10.466643	2
59	9.533704	9.973032	9.560673	10.439327	10.026968	10.466296	1
60	9.534052	9.972986	9.561066	10.438934	10.027014	10.465948	0
		Sine		Tangent		Secant	Minutes

70 *Degrees.*

20 *Degrees*

Minutes	Sine		Tangent		Secant		
0	9.534052	9.972986	9.561066	10.438934	10.027014	10.465948	60
1	9.534399	9.972940	9.561459	10.438541	10.027060	10.465601	59
2	9.534745	9.972894	9.561851	10.438149	10.027106	10.465255	58
3	9.535091	9.972848	9.562244	10.437756	10.027152	10.464908	57
4	9.535437	9.972802	9.562636	10.437364	10.027198	10.464562	56
5	9.535783	9.972755	9.563028	10.436972	10.027245	10.464217	55
6	9.536129	9.972709	9.563419	10.436581	10.027291	10.463871	54
7	9.536474	9.972663	9.563811	10.436189	10.027337	10.463526	53
8	9.536818	9.972617	9.564202	10.435798	10.027383	10.463182	52
9	9.537163	9.972570	9.564592	10.435408	10.027430	10.462837	51
10	9.537507	9.972524	9.564983	10.435017	10.027476	10.462493	50
11	9.537851	9 972477	9.565373	10.434627	10.027523	10.462149	49
12	9.538194	9.972431	9.565763	10.434237	10.027569	10.461806	48
13	9.538537	9.972384	9.566153	10.433847	10.027615	10.461462	47
14	9.538880	9.972338	9.566542	10.433458	10.027662	10.461120	46
15	9.539223	9.972291	9.566932	10.433068	10.027709	10.460777	45
16	9.539565	9.972245	9.567320	10.432679	10.027755	10.460435	44
17	9.539907	9.972198	9.567709	10.432291	10.027802	10.460093	43
18	9.540249	9.972151	9.568097	10.431902	10.027849	10.459751	42
19	9.540590	9.972105	9.568480	10.431514	10.027895	10.459410	41
20	9.540931	9.972058	9.568873	10.431127	10.027942	10.459069	40
21	9.541272	9.972011	9 569261	10.430739	10.027989	10.458728	39
22	9.541613	9.971964	9.569648	10.430352	10.028036	10.458387	38
23	9.541953	9.971917	9.570035	10.429965	10.028083	10.458047	37
24	9.542293	9.971870	9.570422	10.429578	10.028130	10.457707	36
25	9.542632	9.971823	9.570809	10.429191	10.028177	10.457368	35
26	9.542971	9.971776	9.571195	10.428805	10.028224	10.457029	34
27	9.543310	9.971729	9 571581	10.428419	10.028271	10.456690	33
28	9.543649	9.971682	9.571967	10.428033	10.028318	10.456351	32
29	9.543987	9.971635	9.572352	10.427648	10.028365	10.456013	31
30	9.544325	9.971588	9.572738	10.427262	10.028412	10.455675	30
		Sine		Tangent		Secant	Minutes

69 *Degrees*

20 *Degrees.*

Minutes	Sine		Tangent		Secant		
30	9.544325	9.971588	9.572738	10.427262	10.028412	10.455675	30
31	9.544663	9.971540	9.573123	10.426877	10.028460	10.455337	29
32	9.545001	9.971493	9.573507	10.426493	10.028507	10.454999	28
33	9.545338	9.971446	9.573892	10.426108	10.028554	10.454662	27
34	9.545674	9.971398	9.574276	10.425724	10.028602	10.454326	26
35	9.546011	9.971351	9.574660	10.425340	10.028649	10.453989	25
36	9.546347	9.971303	9.575044	10.424956	10.028697	10.453653	24
37	9.546683	9.971256	9.575427	10.424573	10.028744	10.453317	23
38	9.547019	9.971208	9.575810	10.424190	10.028792	10.452981	22
39	9.547354	9.971161	9.576193	10.423807	10.028839	10.452646	21
40	9.547689	9.971113	9.576576	10.423424	10.028887	10.452311	20
41	9.548024	9.971065	9.576958	10.423042	10.028935	10.451976	19
42	9.548358	9.971018	9.577341	10.422659	10.028982	10.451642	18
43	9.548693	9.970970	9.577723	10.422277	10.029030	10.451307	17
44	9.549027	9.970922	9.578104	10.421896	10.029078	10.450973	16
45	9.549360	9.970874	9.578486	10.421514	10.029126	10.450640	15
46	9.549693	9.970826	9.578867	10.421133	10.029174	10.450307	14
47	9.550026	9.970779	9.579248	10.420752	10.029221	10.449974	13
48	9.550359	9.970731	9.579629	10.420371	10.029269	10.449641	12
49	9.550692	9.970683	9.580009	10.419991	10.029317	10.449308	11
50	9.551024	9.970635	9.580389	10.419611	10.029365	10.448976	10
51	9.551356	9.970586	9.580769	19.419231	10.029414	10.448644	9
52	9.551687	9.970538	9.581149	10.418851	10.029462	10.448313	8
53	9.552018	9.970490	9.581528	10.418472	10.029510	10.447982	7
54	9.552349	9.970442	9.581907	10.418093	10.029558	10.447651	6
55	9.552680	9.970394	9.582286	10.417714	10.029606	10.447320	5
56	9.553010	9.970345	9.582665	10.417335	10.029655	10.446990	4
57	9.553341	9.970297	9.583043	10.416957	10.029703	10.446659	3
58	9.553670	9.970249	9.583422	10.416578	10.029751	10.446330	2
59	9.554000	9.970200	9.583800	10.416200	10.029800	10.446000	1
60	9.554329	9.970152	9.584177	10.415823	10.029848	10.445671	0
		Sine		Tangent		Secant	Minutes

69 *Degrees.*

21 *Degrees*

Minutes	Sine		Tangent		Secant		
0	9.554329	9.970152	9.584177	10.415823	10.029848	10.445671	60
1	9.554658	9.970103	9.584555	10.415445	10.029897	10.445342	59
2	9.554987	9.970055	9.584932	10.415068	10.029945	10 445013	58
3	9.555315	9.970006	9.585309	10.414691	10.029994	10.444685	57
4	9.555643	9.969957	9.585686	10.414314	10.030043	10.444357	56
5	9.555971	9.969909	9.586062	10.413938	10.030091	10.444029	55
6	9.556299	9.969860	9.586439	10.413561	10.030140	10.443701	54
7	9.556626	9.969811	9.586815	10.413185	10.030189	10.443374	53
8	9.556953	9.969762	9.587190	10.412810	10.030238	10.443047	52
9	9.557280	9.969714	9.587566	10.412434	10.030286	10.442720	51
10	9.557606	9.969665	9.587941	10.412059	10.030335	10.442394	50
11	9.557932	9.969616	9.588316	10.411684	10.030384	10.442068	49
12	9.558258	9.969567	9.588691	10.411309	10.030433	10.441742	48
13	9.558583	9.969518	9.589066	10.410934	10.030482	10.441417	47
14	9.558909	9.969469	9.589440	10.410560	10.030531	10.441091	46
15	9.559234	9.969420	9.589814	10.410186	10.030580	10.440766	45
16	9.559558	9.969370	9.590188	10.409812	10.030630	10.440442	44
17	9.559883	9.969321	9.590562	10.409438	10.030679	10.440117	43
18	9.560207	9.969272	9.590935	10.409065	10.030728	10.439793	42
19	9.560531	9.969223	9.591308	10.408692	10.030777	10.439469	41
20	9.560855	9.969173	9.591681	10.408319	10.030827	10.439145	40
21	9.561178	9.969124	9 592054	10.407946	10.030876	10.438822	39
22	9.561501	9.969075	9.592426	10.407574	10.030925	10.438499	38
23	9.561824	9.969025	9.592798	10.407202	10.030975	10.438176	37
24	9.562146	9.968976	9.593170	10.406830	10.031024	10.437854	36
25	9.562468	9.968926	9.593542	10.406458	10.031074	10.437532	35
26	9.562790	9.968877	9.593914	10.406086	10.031123	10.437210	34
27	9.563112	9.968827	9.594285	10.405715	10.031173	10.436888	33
28	9.563433	9.968777	9.594656	10.405344	10.031223	10.436566	32
29	9.563755	9.968728	9.595027	10.404973	10.031272	10.436245	31
30	9.564075	9.968678	9.595397	10.404603	10.031322	10.435925	30
		Sine		Tangent		Secant	Minutes

68 *Degrees*

21 *Degrees.*

Minutes	Sine		Tangent		Secant		
30	9.564075	9.968678	9.595397	10.404603	10.031322	10.435925	30
31	9.564396	9.968628	9.595768	10.404232	10.031372	10.435604	29
32	9.564716	9.968578	9.596138	10.403862	10.031422	10 435284	28
33	9.565036	9.968528	9.596508	10.403492	10.031472	10.434964	27
34	9,565356	9 968478	9.596878	10.403122	10.031521	10.434644	26
35	9.565676	9.968429	9.597247	10.402753	10.031571	10.434324	25
36	9.565995	9.968379	9.597616	10 402384	10.031621	10.434005	24
37	9.566314	9.968328	9.597985	10.402015	10.031672	10.433686	23
38	9.566632	9.968278	9.598354	10.401646	10.031722	10.433368	22
39	9.566951	9.968228	9.598722	10.401278	10.031772	10.433049	21
40	9.567269	9.968178	9.599091	10.400909	10.031822	10.432731	20
41	9.567587	9.968128	9.599459	10.400541	10.031872	10.432413	19
42	9.567904	9.968078	9.599827	10.400173	10.031922	10.432096	18
43	9.568222	9.968027	9.600194	10.399806	10.031973	10.431778	17
44	9.568539	9.967977	9.600562	10.399438	10.032023	10.431461	16
45	9.568855	9.967927	9.600929	10.399071	10.032073	10.431145	15
46	9.569172	9.967876	9.601296	10.398704	10.032124	10.430828	14
47	9.569488	9.967826	9 601662	10.398338	10.032174	10.430512	13
48	9.569804	9.967775	9 602029	10.397971	10.032225	10.430196	12
49	9 570120	9.967725	9.602395	10.397605	10.032275	10.429880	11
50	9.570435	9.967674	9.602761	10.397239	10.032320	10.429565	10
51	9.570751	9.967623	9.603127	19.396873	10.032377	10.429249	9
52	9.571066	9.967573	9.603493	10.396507	10.032427	10.428934	8
53	9.571380	9.967522	9.603858	10 396142	10.032478	10.428620	7
54	9.571695	9.967471	9.604223	10.395777	10.032529	10.428305	6
55	9.572009	9.967420	9.604588	10.395412	10.032580	10.427991	5
56	9.572323	9.967370	9.604953	10.395047	10.032630	10.427677	4
57	9.572636	9.967319	9.605317	10.394683	10.032681	10.427364	3
58	9.572949	9.967268	9.605682	10.394318	10.032732	10.427051	2
59	9.573262	9.967217	9.606046	10.393954	10.032783	10.426738	1
60	9.573575	9.967166	9.606410	10.393590	10.032834	10.426425	0
		Sine		Tangent		Secant	Minutes

68 *Degrees.*

22 *Degrees*

Minutes	Sine		Tangent		Secant		
0	9.573575	9.967106	9.606410	0.393590	10.032834	10.426425	60
1	9.573888	9.967115	9.606773	10.393227	10.032885	10.426112	59
2	9.574200	9.967064	9.607137	10.392863	10.032936	10 425800	58
3	9.574512	9.967012	9.607500	10.392500	10.032987	10.425488	57
4	9.574824	9.966961	9.607863	10.392137	10.033039	10.425176	56
5	9.575136	9.966910	9.608225	10.391775	10.033090	10.424884	55
6	9.575447	9.966859	9.608588	10.391412	10.033141	10.424553	54
7	9.575758	9.966807	9.608950	10.391050	10.033192	10.424242	53
8	9.576068	9.966756	9.609312	10.390688	10.033244	10.423931	52
9	9.576379	9.966705	9.609674	10.390326	10.033295	10.423621	51
10	9.576689	9.966653	9.610036	10.389964	10.033347	10.423311	50
11	9.576999	9 966602	9.610397	10.389603	10.033398	10.423001	49
12	9.577309	9.966550	9.610759	10.389241	10.033450	10.422691	48
13	9.577618	9.966499	9.611122	10.388880	10.033501	10.422382	47
14	9.577927	9.966447	9.611480	10.388520	10.033553	10.422072	46
15	9.578236	9.966395	9.611841	10.388159	10.033605	10.421764	45
16	9.578545	9.966344	9.612201	10.387799	10.033656	10.421455	44
17	9.578853	9.966292	9.612561	10.387438	10.033708	10.421146	43
18	9.579162	9.966240	9.612921	10.387079	10.033760	10.420838	42
19	9.579469	9.966188	9.613281	10.386719	10.033812	10.420530	41
20	9.579777	96.66136	9.613641	10.386359	10.033863	10.410223	40
21	9.580084	9.966085	9 614000	10.386000	10.033915	10.419915	39
22	9.580392	9.966033	9.614359	10.385641	10.033967	10.419608	38
23	9.580699	9.965981	9.614718	10.385282	10.034019	10.419301	37
24	9.581005	9.965928	9.615077	10.384923	10.034071	10.418995	36
25	9.581312	9.965876	9.615435	10.384565	10.034124	10.418688	35
26	9.581818	9.965824	9.615793	10.384207	10.034176	10.418382	34
27	9.581924	9.965772	9 616151	10.383849	10.034228	10.418076	33
28	9.582229	9.965720	9.616509	10.383491	10.034280	10.417771	32
29	9.582534	9.965668	9.616867	10.383133	10.034332	10.417465	31
30	9.582840	9.965615	9.617224	10.382776	10.034385	10.417160	30
		Sine		Tangent		Secant	Minutes

67 *Degrees*

22 Degrees.

Minutes	Sine		Tangent		Secant		
30	9.582840	9.965615	9.617224	10.382776	10.034385	10.417160	30
31	9.583144	9.965563	9.617581	10.382418	10.034437	10.416855	29
32	9.583449	9.965511	9.617938	10.382061	10.034489	10.416551	28
33	9.583753	9.965458	9.618295	10.381705	10.034542	10.416246	27
34	9.584058	9.965406	9.618652	10.381348	10.034594	10.415942	26
35	9.584361	9.965353	9.619008	10.380992	10.034647	10.415638	25
36	9.584665	9.965301	9.619364	10.380635	10.034699	10.415335	24
37	9.584968	9.965248	9.619720	10.380279	10.034752	10.415031	23
38	9.585272	9.965195	9.620076	10.379924	10.034805	10.414728	22
39	9.585574	9.965143	9.620432	10.379568	10.034857	10.414425	21
40	9.585877	9.965090	9.620787	10.379213	10.034910	10.414123	20
41	9.586179	9.965037	9.621142	10.378858	10.034963	10.413820	19
42	9.586482	9.964984	9.621497	10.378503	10.035016	10.413518	18
43	9.586783	9.964931	9.621852	10.378148	10.035069	10.413216	17
44	9.587085	9.964878	9.622207	10.377793	10.035121	10.412915	16
45	9.587386	9.964826	9.622561	10.377439	10.035174	10.412613	15
46	9.587688	9.964773	9.622915	10.377085	10.035227	10.412312	14
47	9.587988	9.964719	9.623269	10.376731	10.035280	10.412011	13
48	9.588289	9.964666	9.623623	10.376377	10.035333	10.411711	12
49	9.588590	9.964613	9.623976	10.376024	10.035387	10.411410	11
50	9.588890	9.964560	9.624330	10.375670	10.035440	10.411110	10
51	9.589190	9.964507	9.624683	10.375317	10.035493	10.410810	9
52	9.589489	9.964454	9.625036	10.374964	10.035546	10.410511	8
53	9.589789	9.964400	9.625388	10.374612	10.035600	10.410211	7
54	9.590088	9.964347	9.625741	10.374259	10.035653	10.409912	6
55	9.590387	9.964294	9.626093	10.373907	10.035707	10.409613	5
56	9.590686	9.964240	9.626445	10.373555	10.035760	10.409314	4
57	9.590984	9.964187	9.626797	10.373203	10.035813	10.409016	3
58	9.591282	9.964133	9.627149	10.372851	10.035867	10.408718	2
59	9.591580	9.964080	9.627501	10.372499	10.035920	10.408420	1
60	9.591878	9.964026	9.627852	10.372148	10.035974	10.408122	0
		Sine		Tangent		Secant	Minutes

67 Degrees.

23 *Degrees*

Minutes	Sine		Tangent		Secant		
0	9.591878	9.964026	9.627852	10.372148	10.035974	10.408122	60
1	9.592175	9.963972	9.628203	10.371797	10.036028	10.407825	59
2	9.592473	9.963919	9.628554	10.371446	10.036081	10.407527	58
3	9.592770	9.963865	9.628905	10.371095	10.036135	10.407230	57
4	9.593067	9.963811	9.629255	10.370745	10.036189	10.406933	56
5	9.593363	9.963757	9.629606	10.370394	10.036243	10.406637	55
6	9.593659	9.963704	9.629956	10.370044	10.036296	10.406341	54
7	9.593955	9.963650	9.630306	10.369694	10.036350	10.406045	53
8	9.594251	9.963596	9.630656	10.369344	10.036404	10.405749	52
9	9.594547	9.963542	9.631005	10.368995	10.036458	10.405453	51
10	9.594842	9.963488	9.631354	10.368646	10.036512	10.405158	50
11	9.595137	9.963434	9.631704	10.368296	10.036566	10.404863	49
12	9.595432	9.963379	9.632053	10.367947	10.036621	10.404568	48
13	9.595727	9.963325	9.632401	10.367599	10.036675	10.404273	47
14	9.596021	9.963271	9.632750	10.367250	10.036729	10.403979	46
15	9.596315	9.963217	9.633098	10.366902	10.036783	10.403685	45
16	9.596609	9.963162	9.633447	10.366553	10.036838	10.403391	44
17	9.596903	9.963108	9.633795	10.366205	10.036892	10.403097	43
18	9.597196	9.963054	9.634143	10.365857	10.036946	10.402804	42
19	9.597490	9.962999	9.634490	10.365510	10.037001	10.402510	41
20	9.597783	9.962945	9.634838	10.365162	10.037055	10.402217	40
21	9.598075	9.962890	9.635185	10.364815	10.037110	10.401925	39
22	9.598368	9.962836	9.635532	10.364468	10.037164	10.401632	38
23	9.598660	9.962781	9.635879	10.364121	10.037219	10.401340	37
24	9.598952	9.962727	9.636226	10.363774	10.037273	10.401048	36
25	9.599244	9.962672	9.636572	10.363428	10.037328	10.400756	35
26	9.599536	9.962617	9.636918	10.363082	10.037383	10.400464	34
27	9.599827	9.962562	9.637265	10.362735	10.037438	10.400173	33
28	9.600118	9.962508	9.637611	10.362389	10.037492	10.399882	32
29	9.600409	9.962453	9.637956	10.362044	10.037547	10.399591	31
30	9.600700	9.962398	9.638302	10.361698	10.037602	10.399300	30
		Sine		Tangent		Secant	Minutes

66 *Degrees*

23 Degrees

Minutes	Sine		Tangent		Secant		
30	9.600700	9.962398	9.638302	10.361698	10.037602	10.399300	30
31	9.600990	9.962343	9.638647	10.361353	10.037657	10.399010	29
32	9.601280	9.962288	9.638992	10.361008	10.037712	10.398720	28
33	9.601570	9.962233	9.639337	10.360663	10.037767	10.398430	27
34	9.601860	9.962178	9.639682	10.360318	10.037822	10.398140	26
35	9.602149	9.962123	9.640027	10.359973	10.037877	10.397851	25
36	9.602439	9.962067	9.640371	10.359629	10.037933	10.397561	24
37	9.602728	9.962012	9.640716	10.359284	10.037988	10.397272	23
38	9.603017	9.961957	9.641060	10.358940	10.038043	10.396983	22
39	9.603305	9.961902	9.641404	10.358596	10.038098	10.396695	21
40	9.603594	9.961846	9.641747	10.358253	10.038154	10.396406	20
41	9.603882	9.961791	9.642091	10.357909	10.038209	10.396118	19
42	9.604170	9.961735	9.642434	10 357566	10.038265	10.395830	18
43	9.604457	9.961680	9.642777	10.357223	10.038320	10.395543	17
44	9.604745	9.961624	9.643120	10.356880	10.038376	10.395255	16
45	9.605032	9.961569	9.643463	10.356537	10.038431	10.394968	15
46	9.605319	9.961513	9.643806	10.356194	10.038487	10.394681	14
47	9.605606	9.961458	9.644148	10.355852	10.038542	10.394394	13
48	9.605892	9.961402	9.644490	10.355510	10.038598	10.394108	12
49	9.606179	9.961346	9.644832	10.355168	10.038654	10.393821	11
50	9.606465	9.961290	9.645174	10.354826	10.038710	10.393535	10
51	9.606751	9.961235	9.645516	10.354484	10.038765	10.393249	9
52	9.607036	9.961179	9.645857	10.354143	10.038821	10.392964	8
53	9.607322	9.961123	9.646199	10.353801	10.038877	10.392678	7
54	9.607607	9.961067	9.646540	10.353460	10.038933	10.392393	6
55	9.607892	9.961011	9.646881	10.253119	10.038989	10.392108	5
56	9.608176	9.960955	9.647222	10.352778	10.039045	10.391824	4
57	9.608461	9.960899	9.647562	10.352438	10.039101	10.391539	3
58	9.608745	9.960843	9.647903	10.352097	10.039157	10.391255	2
59	9.609029	9.960786	9.648243	10.351757	10.039214	10.390971	1
60	9.609313	9.960730	9.648583	10.351417	10.039270	10.390687	0
		Sine		Tangent		Secant	Minutes

66 Degrees.

24 *Degrees*

Minutes	Sine		Tangent		Secant		
0	9.609313	9.960730	9.648583	10.351417	10.039270	10.390687	60
1	9.609597	9.960674	9.648923	10.351077	10.039326	10.390403	59
2	9.609880	9.960618	9.649263	10.350737	10.039382	10.390120	58
3	9.610163	9.960561	9.649602	10.350398	10.039439	10.389836	57
4	9.610446	9.960505	9.649942	10.350058	10.039495	10.389553	56
5	9.610729	9.960448	9.650281	10.349719	10.039552	10.389271	55
6	9.611012	9.960392	9.650620	10.349380	10.039608	10.388988	54
7	9.611294	9.960335	9.650959	10.349041	10.039665	10.388706	53
8	9.611576	9.960279	9.651297	10.348703	10.039721	10.388424	52
9	9.611858	9.960222	9.651636	10.348364	10.039778	10.388142	51
10	9.612140	9.960165	9.651974	10.348026	10.039834	10.387860	50
11	9.612421	9.960109	9.652312	10.347688	10.039891	10.387579	49
12	9.612702	9.960052	9.652650	10.347350	10.039948	10.387298	48
13	9.612983	9.959995	9.652988	10.347012	10.040005	10.387017	47
14	9.613264	9.959938	9.653326	10.346674	10.040062	10.386736	46
15	9.613545	9.959881	9.653663	10.346337	10.040118	10.386455	45
16	9.613825	9.959825	9.654000	10.346000	10.040175	10.386175	44
17	9.614105	9.959768	9.654337	10.345662	10.040232	10.385895	43
18	9.614385	9.959711	9.654674	10.345326	10.040289	10.385615	42
19	9.614605	9.959653	9.655011	10.344989	10.040346	10.385335	41
20	9.614944	9.959596	9.655348	10.344652	10.040404	10.385956	40
21	9.615223	9.959539	9.655684	10.344316	10.040461	10.384777	39
22	9.615502	9.959482	9.656020	10.343980	10.040518	10.384498	38
23	9.615781	9.959425	9.656356	10.343644	10.040575	10.384219	37
24	9.616060	9.959367	9.656692	10.343308	10.040632	10.383940	36
25	9.616338	9.959310	9.657028	10.342972	10.040690	10.383662	35
26	9.616616	9.959253	9.657364	10.342636	10.040747	10.383384	34
27	9.616894	9.959195	9.657699	10.342301	10.040805	10.383106	33
28	9.617172	9.959138	9.658034	10.341966	10.040862	10.382828	32
29	9.617450	9.959081	9.658369	10.341631	10.040919	10.382550	31
30	9.617727	9.959023	9.658704	10.341296	10.040977	10.382273	30
		Sine		Tangent		Secant	Minutes

65 *Degrees.*

24 *Degrees*

Minutes	Sine		Tangent		Secant		
30	9.617727	9.959023	9.653704	10.341296	10.040977	10.382273	30
31	9.618004	9.958965	9.659039	10.340961	10.041035	10.381996	29
32	9.618281	9.958908	9.659373	10.340627	10.041092	10.381719	28
33	9.618558	9.958850	9.659708	10.340292	10.041150	10.381442	27
34	9.618824	9.958792	9.660042	10.339958	10.041208	10.381166	26
35	9.619110	9.958734	9.660376	10.339624	10.041266	10.380890	25
36	9.619386	9.958677	9.660710	10.339290	10.041323	10.380614	24
37	9.61966	9.958619	9.661043	10.338957	10.041381	10.380338	23
38	9.619938	9.95856	9.661377	10.338623	10.041439	10.380062	22
39	9.620213	9.958503	9.661710	10.338290	10.041497	10.389787	21
40	9.620488	9.958445	9.662043	10.337957	10.041555	10.379512	2
41	9.620763	9.958387	9.662376	10.337623	10.041613	10.379237	19
42	9.621038	9.958329	9.662709	10 337291	10.041671	10.378962	18
43	9.621313	9.95827	9.663042	10.336958	10.041729	10.378687	17
44	9.621587	9.958212	9.663374	10.336625	10.041788	10.378413	16
45	9.621861	9.958154	9.663707	10.336293	10.041846	10.378139	15
46	9.622135	9.958096	9.664039	10.335961	10.041904	10.377865	14
47	9.622409	9.958038	9.664371	10.335629	10.041962	10.377591	13
48	9.622682	9.957979	9.664703	10.335297	10.042021	10.377318	12
49	9.622956	9.957921	9.665035	10.334965	10.042079	10.377044	11
50	9.623229	9.957863	9.665366	10.334634	10.042137	10.376771	10
51	9.623502	9.957804	9.665697	10.334303	10.042196	10.376498	9
52	9.623774	9.957746	9.666029	10.333971	10.042254	10.376226	8
53	9.624047	9.957687	9.666360	10.333640	10.042313	10.375953	7
54	9.624319	9.957628	9.666691	10.333309	10.042372	10.375681	6
55	9.624591	9.957570	9.667021	10.332979	10.042430	10.375409	5
56	9.624863	9.957511	9.667352	10.332648	10.042489	10.375137	4
57	9.625135	9.957452	9.667682	10.332318	10.042548	10.374865	3
58	9.625406	9.957393	9.668013	10.331987	10.042607	10.374594	2
59	9.625677	9.957335	9.668343	10.331657	10.042665	10.374323	1
60	9.625948	9.957276	9.668672	10.331327	10.042724	10.374052	0
		Sine		Tangent		Secant	Minutes

65 *Degrees.*

25 *Degrees*

Minutes	Sine		Tangent		Secant		
0	9.625948	9.957276	9.668672	10.331328	10.042724	10.374052	60
1	9.626219	9.957217	9.669002	10.330998	10.042783	10.373781	59
2	9.62649	9.957158	9.669332	10.330668	10.042842	10.373510	58
3	9.626760	9.957099	9.669661	10.330339	10.042901	10.373240	57
4	9.627030	9.957040	9.669991	10.330009	10.042960	10.372970	56
5	9.627300	9.956981	9.670320	10.329680	10.043019	10.372700	55
6	9.627570	9.956921	9.670649	10.329351	10.043078	10.372430	54
7	9.627840	9.956862	9.670977	10.329023	10.043138	10.372160	53
8	9.628109	9.956803	9.671306	10.328694	10.043197	10.371891	52
9	9.628378	9.956744	9.671634	10.328366	10.043256	10.371622	51
10	9.628647	9.956684	9.671963	10.328037	10.043316	10.371353	50
11	9.628916	9.956625	9.672291	10.327709	10.043375	10.371084	49
12	9.629184	9.956566	9.672619	10.327381	10.043434	10.370816	48
13	9.629453	9.956506	9.672947	10.327053	10.043494	10.370547	47
14	9.629721	9.956447	9.673274	10.326726	10.043553	10.370279	46
15	9.629989	9.956387	9.673602	10.326398	10.043613	10.370011	45
16	9.630257	9.956327	9.673929	10.326071	10.043673	10.369743	44
17	9.630524	9.956268	9.674257	10.325743	10.043732	10.369476	43
18	9.630792	9.956208	9.674584	10.325416	10.043792	10.369208	42
19	9.631059	9.956148	9.674910	10.325090	10.043852	10.368941	41
20	9.631326	9.956089	9.675237	10.324763	10.043911	10.368674	40
21	9.631593	9.956029	9.675564	10.324436	10.043971	10.368407	39
22	9.631859	9.955969	9.675890	10.324110	10.044031	10.368141	38
23	9.632125	9.955909	9.676216	10.323784	10.044091	10.367874	37
24	9.632392	9.955849	9.676543	10.323457	10.044151	10.367608	36
25	9.632658	9.955789	9.676869	10.323131	10.044211	10.367342	35
26	9.632923	9.955729	9.677194	10.322806	10.044271	10.367077	34
27	9.633189	9.955669	9.677520	10.322480	10.044331	10.366811	33
28	9.633454	9.955609	9.677846	10.322154	10.044391	10.366546	32
29	9.633719	9.955548	9.678171	10.321829	10.044452	10.366281	31
30	9.633984	9.955488	9.678496	10.321504	10 044512	10.366016	30
		Sine		Tangent		Secant	Minutes

64 *Degrees.*

25 *Degrees.*

Minutes	Sine		Tangent		Secant		
30	9.633984	9.955488	9.678496	10.321504	10.044512	10.366016	30
31	9.634249	9.955428	9.678821	10.321179	10.044572	10.365751	29
32	9.634514	9.955368	9.679146	10.320854	10.044632	10.365486	28
33	9.634778	9.955307	9.679471	10.320529	10.044693	10.365222	27
34	9.635042	9.955247	9.679795	10.320205	10.044753	10.364958	26
35	9.635306	9.955186	9.680120	10.319880	10.044814	10.364694	25
36	9.635570	9.955126	9.680444	10.319556	10.044874	10.364430	24
37	9.635833	9.955065	9.680768	10.319232	10.044935	10.364167	23
38	9.636097	9.955005	9.681092	10.318908	10.044995	10.363903	22
39	9.636360	9.954944	9.681416	10.318584	10.045056	10.363640	21
40	9.636623	9.954883	9.681740	10.318260	10.045117	10.363377	20
41	9.636886	9.954823	9.682063	10.317937	10.045177	10.363114	19
42	9.637148	9.954762	9.682386	10.317614	10.045238	10.362852	18
43	9.637411	9.954701	9.682710	10.317290	10.045299	10.362589	17
44	9.637673	9.954640	9.683033	10.316967	10.045360	10.362327	16
45	9.637935	9.954579	9.683356	10.316644	10.045421	10.362065	15
46	9.638197	9.954518	9.683678	10.316322	10.045482	10.361803	14
47	9.638458	9.954457	9.684001	10.315999	10.045543	10.361541	13
48	9.638720	9.954396	9.684324	10.315676	10.045604	10.361280	12
49	9.638981	9.954335	9.684646	10.315354	10.045665	10.361019	11
50	9.639242	9.954274	9.684968	10.315032	10.045726	10.360758	10
51	9.639503	9.954213	9.685290	10.314710	10.045787	10.360497	9
52	9.639764	9.954152	9.685612	10.314388	10.045848	10.360236	8
53	9.640024	9.954090	9.685934	10.314066	10.045910	10.359976	7
54	9.640284	9.954029	9.686255	10.313745	10.045971	10.359716	6
55	9.640544	9.953968	9.686577	10.313423	10.046032	10.359456	5
56	9.640804	9.953906	9.686898	10.313102	10.046094	10.359196	4
57	9.641064	9.953845	9.687219	10.312781	10.046155	10.358936	3
58	9.641323	9.953783	9.687540	10.312460	10.046217	10.358677	2
59	9.641583	9.953722	9.687861	10.312139	10.046278	10.358417	1
60	9.641842	9.953660	9.688182	10.311818	10.046340	10.358158	0
		Sine		Tangent		Secant	Minutes

64 *Degrees.*

26 *Degrees*

Minutes	Sine		Tangent		Secant		
0	9.641842	9.953660	9.688182	10.311818	10.046340	10.358158	60
1	9.642101	9.953598	9.688502	10.311598	10.046401	10.357899	59
2	9.642360	9.953537	9.688823	10.311177	10.046463	10.357640	58
3	9.642618	9.953475	9.689143	10.310857	10.046525	10.357382	57
4	9.642876	9.953413	9.689463	10.310537	10.046587	10.357123	56
5	9.643135	9.953351	9.689783	10.310217	10.046648	10.356865	55
6	9.643393	9.953290	9.690103	10.309897	10.046710	10.356607	54
7	9.643650	9.953228	9.690423	10.309577	10.046772	10.356350	53
8	9.643908	9.953166	9.690742	10.309258	10.046834	10.356092	52
9	9.644165	9.953104	9.691062	10.308938	10.046896	10.355835	51
10	9.644423	9.953042	9.691381	10.308619	10.046958	10.355577	50
11	9.644680	9.952980	9.691700	10.308300	10.047020	10.355320	49
12	9.644936	9.952917	9.692019	10.307981	10.047082	10.355063	48
13	9.645193	9.952855	9.692338	10.307662	10.047145	10.354807	47
14	9.645450	9.952793	9.692656	10.307343	10.047207	10.354550	46
15	9.645706	9.952731	9.692975	10.307025	10.047269	10.354294	45
16	9.645962	9.952668	9.693293	10.306707	10.047331	10.354038	44
17	9.646218	9.952606	9.693612	10.306388	10.047394	10.353782	43
18	9.646473	9.952544	9.693930	10.306070	10.047456	10.353526	42
19	9.646729	9.952481	9.694248	10.305752	10.047519	10.353271	41
20	9.646984	9.952419	9.694566	10.305434	10.047581	10.353016	40
21	9.647239	9.952356	9.694883	10.305117	10.047644	10.352760	39
22	9.647494	9.952294	9.695201	10.304799	10.047706	10.352505	38
23	9.647749	9.952231	9.695518	10.304482	10.047769	10.352251	37
24	9.648004	9.952168	9.695835	10.304164	10.047832	10.351996	36
25	9.648258	9.952105	9.696153	10.303847	10.047894	10.351742	35
26	9.648512	9.952043	9.696470	10.303530	10.047957	10.351488	34
27	9.648766	9.952980	9.696786	10.303213	10.048020	10.351233	33
28	9.649020	9.952917	9.697103	10.302897	10.048083	10.350980	32
29	9.649274	9.952854	9.697420	10.302580	10.048146	10.350726	31
30	9.649527	9.952791	9.697736	10.302264	10.048209	10.350473	30
		Sine		Tangent		Secant	Minutes

63 *Degrees*

26 Degrees.

Minutes	Sine		Tangent		Secant		
30	9.649527	9.951791	9.697736	10.302264	10.048209	10.350473	30
31	9.649781	9.951728	9.698053	10.301947	10.048272	10.350219	29
32	9.650034	9.951665	9.698369	10.301631	10.048335	10.349966	28
33	9.650287	9.951602	9.698685	10.301315	10.048398	10.349713	27
34	9.650539	9.951539	9.699001	10.300999	10.048461	10.349460	26
35	9.650792	9.951476	9.699316	10.300684	10.048524	10.349208	25
36	9.651044	9.951412	9.699632	10.300368	10.048588	10.348950	24
37	9.651297	9.951349	9.699947	10.300053	10.048651	10.348703	23
38	9.651549	9.951286	9.700263	10.299737	10.048714	10.348451	22
39	9.651800	9.951222	9.700578	10.299422	10.048778	10.348200	21
40	9.652052	9.951159	9.700893	10.299107	10.048841	10.347948	20
41	9.652303	9.951096	9.701208	10.298792	10.048904	10.347796	19
42	9.652555	9.951032	9.701523	10.298477	10.048968	10.347445	18
43	9.652806	9.950968	9.701837	10.298163	10.049031	10.347194	17
44	9.653057	9.950905	9.702152	10.297848	10.049095	10.346943	16
45	9.653307	9.950841	9.702466	10.297534	10.049159	10.346692	15
46	9.653558	9.950777	9.702780	10.297219	10.049222	10.346442	14
47	9.653808	9.950714	9.703095	10.296905	10.049286	10.346192	13
48	9.654059	9.950650	9.703409	10.296591	10.049350	10.345941	12
49	9.654309	9.950586	9.703722	10.296277	10.049414	10.345691	11
50	9.654558	9.950522	9.704036	10.295964	10.049478	10.345442	10
51	9.654808	9.950458	9.704350	10.295650	10.049542	10.345192	9
52	9.655057	9.950394	9.704663	10.295337	10.049606	10.344942	8
53	9.655307	9.950330	9.704976	10.295023	10.049670	10.344693	7
54	9.655556	9.950266	9.705290	10.294710	10.049734	10.344444	6
55	9.655805	9.950202	9.705603	10.294397	10.049798	10.344195	5
56	9.656054	9.950138	9.705916	10.294084	10.049862	10.343946	4
57	9.656302	9.950074	9.706228	10.293772	10.049926	10.343698	3
58	9.656550	9.950009	9.706541	10.293459	10.049990	10.343449	2
59	9.656799	9.949945	9.706853	10.293146	10.050055	10.343201	1
60	9.657047	9.949881	9.707166	10.292834	10.050119	10.342953	0
		Sine		Tangent		Secant	Minutes

63 Degrees.

27 *Degrees*

Minutes	Sine		Tangent		Secant		
0	9.657047	9.949881	9.707166	10.292834	10.050119	10.342953	60
1	9.657295	9.949816	9.707478	10.292522	10.050184	10.342705	59
2	9.657542	9.949752	9.707790	10.292210	10.050248	10.342458	58
3	9.657790	9.949688	9.708102	10.291898	10.050312	10.342210	57
4	9.658037	9.949623	9.708414	10.291586	10.050377	10.341963	56
5	9.658284	9.949558	9.708726	10.291274	10.050442	10.341716	55
6	9.658531	9.949494	9.709037	10.290963	10.050506	10.341469	54
7	9.658778	9.949429	9.709349	10.290651	10.050571	10.341222	53
8	9.659025	9.949364	9.709660	10.290340	10.050636	10.340975	52
9	9.659271	9.949300	9.709971	10.290029	10.050700	10.340729	51
10	9.659517	9.949235	9.710282	10.289718	10 050765	10.340483	50
11	9.659763	9.949170	9.710593	10.289407	10.050830	10.340237	49
12	9.660009	9.949105	9.710904	10.289096	10.050895	10.339991	48
13	9.660255	9.949040	9.711215	10.288785	10.050960	10.339745	47
14	9.660500	9.948975	9.711525	10.288475	10.051025	10.339500	46
15	9.660746	9.948910	9.711836	10.288164	10.051090	10.339254	45
16	9.660991	9.948845	9.712146	10.287854	10.051155	10.339009	44
17	9.661236	9.948780	9.712456	10.287544	10.051220	10.338764	43
18	9.661481	9.948715	9.712766	10.287234	10.051285	10.338519	42
19	9.661726	9.948649	9.713076	10.286924	10.051351	10.338274	41
20	9.661970	9.948584	9.713386	10.286614	10.051416	10.338030	40
21	9.662214	9.948519	9.713696	10.286304	10.051481	10.337786	39
22	9.662459	9.948453	9.714005	10.285995	10.051547	10.337541	38
23	9.662703	9.948388	9.714314	10 285686	10.051612	10.337297	37
24	9.662946	9.948323	9.714624	10.285376	10.051677	10.337054	36
25	9.663190	9.948257	9.714933	10.285067	10.051743	10.336810	35
26	9.663433	9.948192	9.715242	10.284758	10.051808	10.336567	34
27	9.663677	9.948126	9.715551	10.284449	10.051874	10.336323	33
28	9.663920	9.948060	9.715859	10.284141	10.051940	10.336080	32
29	9.564163	9.947995	9.716168	10.283832	10.051005	10.335837	31
30	9.664406	9.947929	9.716477	10.283523	10.051071	10.335594	30
		Sine		Tangent		Secant	Minutes

62 *Degrees*

27 *Degrees.*

Minutes	Sine		Tangent		Secant		
30	9.664406	9.947929	9.716477	10.283523	10.052071	10.335594	30
31	9.664648	9.947863	9.716785	10.283215	10.052137	10.335352	29
32	9.664891	9.947797	9.717093	10.282907	10.052203	10.335109	28
33	9.665133	9.947731	9.717401	10.282599	10.052269	10.334867	27
34	9.665375	9.947665	9.717709	10.282291	10.052335	10.334625	26
35	9.665617	9.947599	9.718017	10.281983	10.052401	10.334383	25
36	9.665859	9.947533	9.718325	10.281675	10.052467	10.334141	24
37	9 666100	9.947467	9.718633	10.281367	10.052533	10.333900	23
38	9.666341	9.947401	9.718940	10.281060	10.052599	10.333659	22
39	9.666583	9.947335	9.719248	10.280752	10.052665	10.333417	21
40	9.666824	9.947269	9.719555	10.280445	10.052731	10.333176	20
41	9.667065	9.947203	9.719862	10.280138	10.052797	10.332935	19
42	9.667305	9.947136	9.720169	10.279831	10.052864	10.332695	18
43	9.667546	9.947070	9.720476	10.279524	10.052930	10.332454	17
44	9.667786	9.947004	9.720783	10.279217	10.052996	10.332214	16
45	9.668026	9.946937	9.721089	10.278911	10.053063	10.331974	15
46	9.668266	9.946871	9.721396	10.278604	10.053129	10.331734	14
47	9.668506	9.946804	9.721702	10.278298	10.053196	10.331494	13
48	9.668746	9.946738	9.722008	10.277992	10.053262	10.331254	12
49	9.668986	9.946671	9.722315	10.277685	10.053329	10.331014	11
50	9.669225	9.946604	9.722621	10.277379	10.053396	10.330775	10
51	9.669464	9.946538	9.722927	10.277073	10.053462	10.330536	9
52	9.669703	9.946471	9.723232	10.276768	10.053529	10.330297	8
53	9.669942	9.946404	9.723538	10.276462	10.053596	10.330058	7
54	9.670181	9.946337	9.723844	10.276156	10.053663	10.329819	6
55	9.670419	9.946270	9.724149	10.275851	10.053730	10.329581	5
56	9.670658	9.946203	9.724454	10.275546	10.053797	10.329342	4
57	9.670896	9.946136	9.724759	10.275241	10.053864	10.329104	3
58	9.671134	9.946069	9.725065	10.274935	10.053931	10.328866	2
59	9.671372	9.946002	9.725369	10.274631	10.053998	10.328628	1
60	9.671609	9.945935	9.725674	10.274326	10.054065	10.328391	0
		Sine		Tangent		Secant	Minutes

62 *Degrees.*

28 Degrees.

Minutes	Sine		Tangent		Secant		
0	9.671609	9.945935	9.725674	10.274326	10.054065	10.328391	60
1	9.671847	9.945868	9.725979	10.274021	10.054132	10.328153	59
2	9.672084	9.945800	9.726284	10.273716	10.054199	10.327916	58
3	9.672321	9.945733	9.726588	10.273412	10.054267	10.327679	57
4	9.672558	9.945666	9.726892	10.273107	10.054334	10.327442	56
5	9.672795	9.945598	9.727197	10.272803	10.054401	10.327205	55
6	9.673032	9.945531	9.727501	10.272499	10.054469	10.326968	54
7	9.673268	9.945464	9.727805	10.272195	10.054536	10.326732	53
8	9.673505	9.945396	9.728109	10.271891	10.054604	10.326495	52
9	9.673741	9.945328	9.728412	10.271588	10.054671	10.326259	51
10	9.673977	9.945261	9.728716	10.271284	10.054739	10.326023	50
11	9.674213	9.945193	9.729020	10.270980	10.054807	10.325787	49
12	9.674448	9.945125	9.729323	10.270677	10.054874	10.325552	48
13	9.674684	9.945058	9.729626	10.270374	10.054942	10.325316	47
14	9.674919	9.944990	9.729929	10.270070	10.055010	10.325081	46
15	9.675155	9.944922	9.730232	10.269767	10.055078	10.324845	45
16	9.675390	9.944854	9.730535	10.269465	10.055146	10.324610	44
17	9.675624	9.944786	9.730838	10.269162	10.055214	10.324375	43
18	9.675859	9.944718	9.731141	10.268859	10.055282	10.324141	42
19	9.676094	9.944650	9.731444	10.268556	10.055350	10.323906	41
20	9.676328	9.944582	9.731746	10.268254	10.055418	10.323672	40
21	9.676562	9.944514	9.732048	10.267952	10.055486	10.323438	39
22	9.676796	9.944446	9.732351	10.267649	10.055554	10.323204	38
23	9.677030	9.944377	9.732653	10.267347	10.055622	10.322970	37
24	9.677264	9.944309	9.732955	10.267045	10.055691	10.322736	36
25	9.677497	9.944241	9.733257	10.266743	10.055759	10.322502	35
26	9.677731	9.944172	9.733558	10.266442	10.055827	10.322269	34
27	9.677964	9.944104	9.733860	10.266140	10.055896	10.322036	33
28	9.678197	9.944036	9.734162	10.265838	10.055964	10.321803	32
29	9.678430	9.943967	9.734463	10.265537	10.056033	10.321570	31
30	9.678663	9.943898	9.734764	10.265236	10.056101	10.321337	30
		Sine		Tangent		Secant	Minutes

61 Degrees.

28 *Degrees.*

Minutes	Sine		Tangent		Secant		
30	9.678663	9.943898	9.734764	10.265236	10.056101	10.32 337	30
31	9.678895	9.943830	9.735066	10.264934	10.056170	10.321104	29
32	9.679128	9.943761	9.735367	10.264633	10.056239	10.320872	28
33	9.679360	9.943692	9.735668	10.264332	10.056307	10.320640	27
34	9.679592	9.943624	9.735968	10.264031	10.056376	1 .320408	26
35	9.679824	9.943555	9.736269	10.263731	10.056445	10.320176	25
36	9.680056	9.943486	9.736570	10.263430	10 056514	0.319944	24
37	9 680288	9.943417	9.736870	10.263129	10.056583	10.319712	23
38	9.680519	9.943348	9.737171	10.262829	10.056652	10.319481	22
39	9.680750	9.943279	9.737471	10.262529	10.056721	10.319250	21
40	9.680982	9.943210	9.737771	10.262229	10.056790	10.319018	20
41	9.681213	9.943141	9.738071	10.261929	0.056859	10.318787	19
42	9.681443	9.943072	9.738371	10.261629	10.056928	10.318557	18
43	9.681674	9.943003	9.738671	10.261329	10.056997	10.318326	17
44	9.681905	9.942933	9.738971	10.261029	0.057066	10.318095	16
45	9.682135	9.942864	9.739271	10.260729	10.057136	10.317865	15
46	9.682365	9.942795	9.739570	10.260430	0.057205	10.317635	14
47	9.682595	9.942725	9.739870	10.260130	10.057274	10.317405	13
48	9.682825	9.942656	9.740169	10.259831	0.057344	10.317175	12
49	9.683055	9.942587	9.740468	10.259532	10.057413	10.316945	11
50	9.683284	9.942517	9.740767	10.259233	10.057483	10.316716	10
51	9.683514	9.942448	9.741066	10.258934	10.057552	10.316486	9
52	9.683743	9.942378	9.741365	10.258635	10.057622	10.316257	8
53	9.683972	9.942308	9.741664	10.258336	10.057692	10.316028	7
54	9.684201	9.942239	9.741962	10.258038	10.057761	0.315799	6
55	9.684430	9.942169	9.742261	10.257739	10.057831	10.315570	5
56	9.684658	9.942099	9.742559	10.257441	10.057901	10.315342	4
57	9.684887	9.942029	9.742858	10.257142	10.057971	10.315113	3
58	9.685115	9.942959	9.743156	10.256844	0.058041	10.314885	2
59	9.685343	9.942889	9.743454	10.256546	10.058111	10.314657	1
60	9.685571	9.942819	9.743752	10.256248	10.058181	10.314429	0
		Sine		Tangent		Secant	Minutes

61 *Degrees.*

29 Degrees.

Minutes	Sine		Tangent		Secant		
0	9.685571	9.941819	9.743752	10.256248	10.058181	10.314429	60
1	9.685799	9.941749	9.744050	10.255950	10.058251	10.314201	59
2	9.686027	9.941679	9.744348	10.255652	10.058321	10.313973	58
3	9.686254	9.941609	9 744645	10.255355	10.058391	10.313746	57
4	9.686482	9.941539	9.744943	10.255057	10.058461	10.313518	56
5	9.686709	9.941468	9.745240	10.254760	10.058532	10.313291	55
6	9.686936	9.941398	9.745538	10.254462	10.058602	10.313064	54
7	9.687163	9.941328	9.745835	10.254165	10.058672	10.312837	53
8	9.687389	9.941258	9.746132	10.253868	10.058742	10.312611	52
9	9.687616	9.941187	9.746429	10.253571	10.058813	10.312384	51
10	9.687842	9.941117	9.746726	10.253274	10.058883	10.312157	50
11	9,688069	9.941046	9.747023	10.252977	10.058954	10.311931	49
12	9.688295	9.940975	9.747319	10.252681	10.059025	10.311705	48
13	9.688521	9.940905	9.747616	10.252384	10.059095	10.311479	47
14	9.688747	9.940834	9.747912	10.252088	10.059166	10.311253	46
15	9.688972	9.940763	9.748209	10.251791	10.059237	10.311028	45
16	9.689198	9.940693	9.748505	10.251495	10.059307	10.310802	44
17	9.689423	9.940622	9.748801	10.251199	10.059378	10.310577	43
18	9.689648	9.940551	9.749097	10.250903	10.059449	10.310352	42
19	9.689873	9.940480	9.749393	10.250607	10.059520	10.310127	41
20	9.690098	9.940409	9.749689	10.250311	10.059591	10.309902	40
21	9.690323	9.940338	9.749985	10.250015	10.059662	10.309677	39
22	9.690548	9.940267	9.750281	10.249719	10.059733	10.309452	38
23	9.690772	9.940196	9.750576	10.249424	10.059804	10.309228	37
24	9,690996	9.940125	9.750872	10.249128	10.059875	10.309004	36
25	9.691220	9.940053	9.751167	10.248833	10.059947	10.308780	35
26	9.691444	9.939982	9.751462	10.248538	10.060018	10.308556	34
27	9.691668	9.939911	9.751757	10.248243	10.060089	10.308332	33
28	9.691892	9.939840	9.752052	10.247948	10.060160	10.308108	32
29	9.692115	9.939768	9.752347	10.247653	10.060232	10.307885	31
30	9.692339	9.939697	9.752642	10.247358	10.060303	10.307661	30
		Sine		Tangent		Secant	Minutes

60 Degrees.

29 Degrees.

Minutes	Sine		Tangent		Secant		
30	9.692339	9.939697	9.752542	10.247358	10.060303	10.307661	30
31	9.692562	9.939625	9.752937	10.247063	10.060375	10.307438	29
32	9.692785	9.939554	9.753231	10.246769	10.060446	10.307215	28
33	9.693009	9.939484	9.753526	10.246474	10.060518	10.306991	27
34	9.693231	9.939410	9.753820	10.246180	10.060590	10.306769	26
35	9.693453	9.939339	9.754115	10.245885	10.060661	10.306547	25
36	9.693676	9.939267	9.754409	10.245591	10.060733	10.306324	24
37	9.693898	9.939195	9.754703	10.245297	10.060805	10.306102	23
38	9.694120	9.939123	9.754997	10.245003	10.060877	10.305880	22
39	9.694342	9.939051	9.755291	10.244709	10.060949	10.305658	21
40	9.694564	9.938980	9.755585	10.244415	10.061020	10.305436	20
41	9.694786	9.938908	9.755878	10.244122	10.061092	10.305214	19
42	9.695007	9.938836	9.756172	10.243828	10.061164	10.304993	18
43	9.695229	9.938763	9.756465	10.243535	10.061237	10.304771	17
44	9.695450	9.938691	9.756759	10.243241	10.061309	10.304550	16
45	9.695671	9.938619	9.757052	10.242948	10.061381	10.304329	15
46	9.695892	9.938547	9.757345	10.242655	10.061453	10.304108	14
47	9.696113	9.938475	9.757638	10.242362	10.061525	10.303887	13
48	9.696334	9.938402	9.757931	10.242069	10.061598	10.303666	12
49	9.696554	9.938330	9.758224	10.241776	10.061670	10.303446	11
50	9.696774	9.938258	9.758517	10.241483	10.061742	10.303226	10
51	9.696995	9.938185	9.758810	10.241190	10.061815	10.303005	9
52	9.697215	9.938113	9.759102	10.240898	10.061887	10.302785	8
53	9.697435	9.938040	9.759395	10.240605	10.061960	10.302565	7
54	9.697654	9.937967	9.759687	10.240313	10.062033	10.302346	6
55	9.697874	9.937895	9.759979	10.240021	10.062105	10.302126	5
56	9.698094	9.937822	9.760272	10.239728	10.062178	10.301906	4
57	9.698313	9.937749	9.760564	10.239436	10.062251	10.301687	3
58	9.698532	9.937676	9.760856	10.239144	10.062324	10.301468	2
59	9.698751	9.937603	9.761148	10.238852	10.062397	10.301249	1
60	9.698970	9.937531	9.761439	10.238561	10.062469	10.301830	0
		Sine		Tangent		Secant	Minutes

60 Degrees.

30 *Degrees.*

Minutes	Sine		Tangent		Secant		
0	9.698970	9.937531	9.761439	10.238561	10.062469	10.301030	60
1	9.699189	9.937458	9.761731	10.238269	10.062541	10.300811	59
2	9.699407	9.937385	9.762023	10.237977	10.062615	10.300593	58
3	9.699626	9.937312	9.762314	10.237686	10.062688	10.300374	57
4	9.699844	9.937238	9.762606	10.237394	10.062762	10.300156	56
5	9.700062	9.937165	9.762897	10.237103	10.062835	10.299938	55
6	9.700280	9.937092	9.763188	10.236812	10.062908	10.299720	54
7	9.700498	9.937019	9.763479	10.236521	10.062981	10.299502	53
8	9.700716	9.936946	9.763770	10.236230	10.063054	10.299284	52
9	9.700933	9.936872	9.764061	10.235939	10.063128	10.299067	51
10	9.701151	9.936799	9.764352	10.235648	10.063201	10.298849	50
11	9.701368	9.936725	9.764643	10.235357	10.063275	10.298632	49
12	9.701585	9.936652	9.764933	10.235067	10.063348	10.298415	48
13	9.701802	9.936578	9.765224	10.234776	10.063422	10.298198	47
14	9.702019	9.936505	9.765514	10.234486	10.063495	10.297981	46
15	9.702236	9.936431	9.765805	10.234195	10.063569	10.297764	45
16	9.702452	9.936357	9.766095	10.233905	10.063643	10.297548	44
17	9.702669	9.936284	9.766385	10.233615	10.063716	10.297331	43
18	9.702885	9.936210	9.766675	10.233325	10.063790	10.297115	42
19	9.703101	9.936136	9.766965	10.233035	10.063864	10.296899	41
20	9.703317	9.936062	9.767255	10.232745	10.063938	10.296683	40
21	9.703533	9.935988	9.767545	10.232455	10.064012	10.296467	39
22	9.703749	9.935914	9.767834	10.232166	10.064086	10.296251	38
23	9.703964	9.935840	9.768124	10.231876	10.064160	10.296036	37
24	9.704179	9.935766	9.768413	10.231587	10.064234	10.295821	36
25	9.704395	9.935692	9.768703	10.231297	10.064308	10.295605	35
26	9.704610	9.935618	9.768992	10.231008	10.064382	10.295390	34
27	9.704825	9.935543	9.769281	10.230719	10.064457	10.295175	33
28	9.705040	9.935469	9.769570	10.230430	10.064531	10.294960	32
29	9.705254	9.935395	9.769860	10.230240	10.064605	10.294746	31
30	9.705469	9.935320	9.770148	10.229852	10.064680	10.294531	30
		Sine		Tangent		Secant	Minutes

59 *Degrees.*

30 Degrees

Minutes	Sine		Tangent		Secant		
30	9.705469	9.935320	9.770148	10.229852	10.064680	10.294531	30
31	9.705683	9.935246	9.770437	10.229563	10.064754	10.294317	29
32	9.705897	9.935171	9.770726	10.229274	10.064829	10.294103	28
33	9.706112	9.935097	9.771015	10.228985	10.064903	10.293888	27
34	9.706326	9.935022	9.771303	10.228697	10.064978	10.293674	26
35	9.706539	9.934948	9.771592	10.228408	10.065052	10.293461	25
36	9.706753	9.934873	9.771880	10.228120	10.065127	10.293247	24
37	9.706967	9.934798	9.772168	10.227832	10.065202	10.293033	23
38	9.707180	9.934723	9.772457	10.227543	10.065277	10.292820	22
39	9.707393	9.934649	9.772745	10.227255	10.065351	10.292607	21
40	9.707606	9.934574	9.773033	10.226967	10.065426	10.292394	20
41	9.707819	9.934499	9.773321	10.226679	10.065501	10.292181	19
42	9.708032	9.934424	9.773608	10 226392	10.065576	10.291968	18
43	9.708245	9.934349	9.773896	10.226104	10.065651	10.291755	17
44	9.708457	9.934274	9.774184	10.225816	10.065726	10.291542	16
45	9.708670	9.934199	9.774471	10.225529	10.065801	10.291330	15
46	9.708882	9.934123	9.774759	10.225241	10.065877	10.291118	14
47	9.709094	9.934048	9.775046	10.224954	10.065952	10.290906	13
48	9.709306	9.933973	9.775333	10.224667	10.066027	10.290694	12
49	9.709518	9.933898	9.775621	10.224379	10.066102	10.290482	11
50	9.709730	9.933822	9.775908	10.224092	10.066178	10.290270	10
51	9.709941	9.933747	9.776195	10.223805	10.066253	10.290059	9
52	9.710153	9.933671	9.776482	10.223518	10.066329	10.289847	8
53	9.710364	9.933596	9.776769	10.223231	10.066404	10.289636	7
54	9.710575	9.933520	9.777055	10.222945	10.066480	10.289425	6
55	9.710786	9.933444	9.777342	10.222658	10.066556	10.289214	5
56	9.710997	9.933369	9.777628	10.222372	10.066631	10.289003	4
57	9.711208	9.933293	9.777915	10.222085	10.066707	10.288792	3
58	9.711419	9.933217	9.778201	10.221799	10.066783	10.288581	2
59	9.711629	9.933141	9.778487	10.221513	10.066859	10.288371	1
60	9.711839	9.933066	9.778774	10.221226	10.066934	10.288161	0
	[illegible]	Sine		Tangent		Secant	Minutes

59 Degrees.

31 *Degrees*

Minutes	Sine		Tangent		Secant		
0	9.711839	9.933066	9.778774	10.221226	10.066934	10.288161	60
1	9.712049	9.932990	9.779060	10.220940	10.067010	10.287951	59
2	9.712260	9.932914	9.779346	10.220654	10.067086	10.287740	58
3	9.712469	9.932838	9.779632	10.220368	10.067162	10.287531	57
4	9.712679	9.932762	9.779918	10.220082	10.067238	10.287321	56
5	9.712889	9.932685	9.780203	10.219797	10.067315	10.287111	55
6	9.713098	9.932609	9.780489	10.219511	10.067391	10.286902	54
7	9.213308	9.932533	9.780775	10.219225	10.067467	10.286692	53
8	9.713517	9.932457	9.781060	10.218940	10.067543	10.286483	52
9	9.713726	9.932380	9.781346	10.218654	10.067620	10.286274	51
10	9.713935	9.932304	9.781631	10.218369	10.067696	10.286065	50
11	9.714144	9.932228	9.781916	10.218084	10.067772	10.285856	49
12	9.714352	9.932151	9.782201	10.217799	10.067849	10.285648	48
13	9.714561	9.932075	9.782486	10.217514	10.067925	10.285439	47
14	9.714769	9.931998	9.782770	10.217300	10.068002	10.285231	46
15	9.714978	9.931921	9.783056	10.216944	10.068079	10.285022	45
16	9.715186	9.931845	9.783341	10.216659	10.068155	10.284814	44
17	9.715394	9.931768	9.783626	10.216374	10.068232	10.284606	43
18	9.715601	9.931691	9.783910	10.216090	10.068309	10.284399	42
19	9.715809	9.931614	9.784195	10.215805	10.068386	10.284191	41
20	9.716017	9.931537	9.784479	10.215521	10.068463	10.283983	40
21	9.716224	9.931460	9.784764	10.215236	10.068540	10.283776	39
22	9.716432	9.931383	9.785048	10.214952	10.068617	10.283568	38
23	9.716639	9.931306	9.785332	10.214668	10.068694	10.283361	37
24	9.716846	9.931229	9.785616	10.214384	10.068771	10.283154	36
25	9.717053	9.931152	9.785900	10.214100	10.068848	10.282947	35
26	9.717259	9.931075	9.786184	10.213816	10.068925	10.282741	34
27	9.717466	9.930998	9.786468	10.213532	10.069002	10.282534	33
28	9.717672	9.930920	9.786752	10.213248	10.069080	10.282328	32
29	9.717879	9.930843	9.787036	10.212964	10.069157	10.282121	31
30	9.718085	9.930766	9.787319	10.212681	10.069234	10.281615	30
		Sine		Tangent		Secant	Minutes

58 *Degrees.*

31 *Degrees*

Minutes	Sine		Tangent		Secant		
30	9.718085	9.930766	9.787319	10.212681	10.069234	10.281915	30
31	9.718291	9.930688	9.787603	10.212397	10.069312	10.281709	29
32	9.718497	9.930611	9.787886	10.212114	10.069389	10.281503	28
33	9.718703	9.930533	9.788170	10.211830	10.069467	10.281297	27
34	9.718909	9.930456	9.788453	10.211547	10.069544	10.281091	26
35	9.719114	9.930378	9.788736	10.211264	10.069622	10.280886	25
36	9.719320	9.930300	9.789019	10.210981	10.069700	10.280680	24
37	9.719525	9.930223	9.789302	10.210698	10.069777	10.280475	23
38	9.719730	9.930145	9.789585	10.210415	10.069855	10.280270	22
39	9.719935	9.920067	9.789868	10.210132	10.069933	10.280065	21
40	9.720140	9.929989	9.790151	10.209849	10.070011	10.279860	20
41	9.720345	9.929911	9.790433	10.209567	10.070089	10.279655	19
42	9.720549	9.929833	9.790716	10 209284	10.070167	10.279451	18
43	9.720754	9.929755	9.790999	10.209001	10.070245	10.279246	17
44	9.720958	9.929677	9.791281	10.208719	10.070323	10.279042	16
45	9.721162	9.929599	9.791563	10.208437	10.070401	10.278838	15
46	9.721366	9.929521	9.791846	10.208154	10.070479	10.278634	14
47	9.721570	9.929442	9.792128	10.207872	10.070558	10.278430	13
48	9.721774	9.929364	9.792410	10.207590	10.070636	10.278226	12
49	9.721678	9.929286	9.792692	10.207308	10.070714	10.278022	11
50	9.722181	9.929207	9.792974	10.207026	10.070793	10.277819	10
51	9.722385	9.929129	9.793256	10.206744	10.070871	10.277615	9
52	9.722588	9.929050	9.793538	10.206462	10.070950	10.277412	8
53	9.722791	9.928972	9.793819	10.206181	10.071028	10.277209	7
54	9.722994	9.928893	9.794101	10.205899	10.071107	10.277006	6
55	9.723197	9.928814	9.794383	10.205617	10.071186	10.276803	5
56	9.723400	9.928736	9.794664	10.205336	10.071264	10.276600	4
57	9.723603	9.928657	9.794945	10.205055	10.071343	10.276397	3
58	9.723805	9.928578	9.795227	10.204773	10.071422	10.276195	2
59	9.724007	9.928499	9.795508	10.204492	10.071501	10.275993	1
60	9.724210	9.928420	9.795789	10.204311	10.071580	10.275790	0
		Sine		Tangent		Secant	Minutes

58 *Degrees.*

32 *Degrees*

Minutes	Sine		Tangent		Secant		
0	9.724210	9.928420	9.795789	10.204211	10.071580	10.275790	60
1	9.724412	9.928341	9.796070	10.203930	10.071659	10.275588	59
2	9.724614	9.928262	9.796351	10.203649	10.071738	10.275386	58
3	9.724816	9.928183	9.796632	10.203368	10.071817	10.275184	57
4	9.725017	9.928104	9.796913	10.203087	10.071896	10.274983	56
5	9.725219	9.928025	9.797194	10.202806	10.071975	10.274781	55
6	9.725420	9.927946	9.797474	10.202526	10.072054	10.274580	54
7	9.725622	9.927867	9.797755	10.202245	10.072133	10.274378	53
8	9.725823	9.927787	9.798036	10.201964	10.072213	10.274177	52
9	9.726024	9.927708	9.798316	10.201684	10.072292	10.273976	51
10	9.726225	9.927628	9.798596	10.201404	10.072372	10.273775	50
11	9.726426	9.927549	9.798877	10.201123	10.072451	10.273574	49
12	9.726626	9.927469	9.799157	10.200843	10.072531	10.273374	48
13	9.726827	9.927390	9.799437	10.200563	10.072610	10.273173	47
14	9.727027	9.927310	9.799717	10.200283	10.072690	10.272973	46
15	9.727228	9.927231	9.799997	10.200003	10.072769	10.272772	45
16	9.727428	9.927151	9.800277	10.199723	10.072849	10.272572	44
17	9.727628	9.927071	9.800557	10.199443	10.072929	10.272372	43
18	9.727828	9.926991	9.800836	10.199164	10.073009	10.272172	42
19	9.728027	9.926911	9.801116	10.198884	10.073089	10.271973	41
20	9.728227	9.926831	9.801396	10.198604	10.073169	10.271773	40
21	9.728427	9.926751	9.801675	10.198325	10.073249	10.271573	39
22	9.728626	9.926671	9.801955	10.198045	10.073329	10.271374	38
23	9.728825	9.926591	9.802234	10.197766	10.073409	10.271175	37
24	9.729024	9.926511	9.802513	10.197487	10.073489	10.270976	36
25	9.729223	9.926431	9.802792	10.197208	10.073569	10.270777	35
26	9.729422	9.926351	9.803072	10.196928	10.073649	10.270578	34
27	9.729621	9.926270	9.803351	10.196649	10.073730	10.270379	33
28	9.729826	9.926190	9.803630	10.196370	10.073810	10.270180	32
29	9.730018	9.926110	9.803908	10.196092	10.073890	10.269982	31
30	9.730210	9.926029	9.804187	10.195813	10.073971	10.269784	30
		Sine		Tangent		Secant	Minutes

57 *Degrees.*

32 *Degrees.*

Minutes	Sine		Tangent		Secant		
30	9.730216	9.926029	9.804187	10.195813	10.073971	10.269784	30
31	9.730415	9.925949	9.804466	10.195534	10.074051	10.269585	29
32	9.730613	9.925868	9.804745	10.195255	10.074132	10.269387	28
33	9.730811	9.925787	9.805023	10.194977	10.074213	10.269189	27
34	9.731009	9.925707	9.805302	10.194698	10.074293	10.268991	26
35	9.731206	9.925626	9.805580	10.194420	10.074374	10.268794	25
36	9.731404	9.925545	9.805859	10.194141	10.074455	10.268596	24
37	9.731601	9.925465	9.806137	10.193863	10.074535	10.268399	23
38	9.731799	9.925384	9.806415	10.193585	10.074616	10.268201	22
39	9.731996	9.925303	9.806693	10.193307	10.074697	10.268004	21
40	9.732193	9.925222	9.806971	10.193029	10.074778	10.267807	20
41	9.732390	9.925141	9.807249	10.192751	10.074859	10.267610	19
42	9.732587	9.925060	9.807527	10.192473	10.074940	10.267413	18
43	9.732784	9.924979	9.807805	10.192195	10.075021	10.267216	17
44	9.732980	9.924897	9.808083	10.191917	10.075103	10.267020	16
45	9.733177	9.924816	9.808361	10.191639	10.075184	10.266823	15
46	9.733373	9.924735	9.808638	10.191362	10.075265	10.266627	14
47	9.733569	9.924653	9.808916	10.191084	10.075347	10.266431	13
48	9.733765	9.924572	9.809193	10.190807	10.075428	10.266235	12
49	9.733961	9.924491	9.809471	10.190529	10.075509	10.266039	11
50	9.734157	9.924409	9.809748	10.190252	10.075591	10.265843	10
51	9.734353	9.924328	9.810025	10.189975	10.075672	10.265647	9
52	9.734548	9.924246	9.810302	10.189698	10.075754	10.265451	8
53	9.734744	9.924164	9.810580	10.189420	10.075836	10.265256	7
54	9.734939	9.924083	9.810857	10.189143	10.075917	10.265061	6
55	9.735134	9.924001	9.811134	10.188866	10.075999	10.264866	5
56	9.735330	9.923919	9.811410	10.188590	10.076081	10.264670	4
57	9.735525	9.923837	9.811687	10.188313	10.076163	10.264475	3
58	9.735719	9.923755	9.811964	10.188036	10.076245	10.264281	2
59	9.735914	9.923673	9.812241	10.187759	10.076327	10.264086	1
60	9.736109	9.923591	9.812517	10.187483	10.076409	10.263891	0
		Sine		Tangent		Secant	Minutes

57 *Degrees.*

33 Degrees

Minutes	Sine		Tangent		Secant		
0	9.736109	9.923591	9.812517	10.187483	10.076409	10.263891	60
1	9.736303	9.923509	9.812794	10.187206	10.076491	10.26369	59
2	9.736498	9.923427	9.813070	10.186930	10.076573	10.263502	58
3	9.736692	9.923345	9.813347	10.186653	10.076655	10.263308	57
4	9.736886	9.923263	9.813623	10.186377	10.076737	10.263114	56
5	9.73798	9.923180	9.813899	10.186101	10.076820	10.262920	55
6	9.737274	9.923198	9.814175	10.185825	10.076902	10.262726	54
7	9.737467	9.923016	9.814452	10.185548	10.076984	10.262533	53
8	9.737661	9.922933	9.814728	10.185272	10.077067	10.262339	52
9	9.737855	9.922851	9.815004	10.184996	10.077149	10.262145	51
10	9.738048	9.922768	9.815279	10.184721	10.077232	10.261952	50
11	9.738241	9.922686	9.815555	10.184445	10.077314	10.261759	49
12	9.738434	9.922603	9.815831	10.184169	10.077397	10.261566	48
13	9.738627	9.922520	9.816107	10.183893	10.077480	10.261373	47
14	9.738820	9.922438	9.816382	10.183618	10.077562	10.261180	46
15	9.739013	9.922355	9.816658	10.183342	10.077645	10.260987	45
16	9.739205	9.922272	9.816933	10.183067	10.077728	10.260795	44
17	9.739398	9.922189	9.817209	10.182791	10.077811	10.260602	43
18	9.739590	9.922106	9.817484	10.182516	10.077894	10.260410	42
19	9.739783	9.922023	9.817759	10.182241	10.077977	10.260217	41
20	9.739975	9.921940	9.818035	10.181965	10.078060	10.260025	40
21	9.740167	9.921857	9.818310	10.181690	10.078143	10.259833	39
22	9.740359	9.921774	9.818585	10.181415	10.078226	10.259641	38
23	9.740550	9.921691	9.818860	10.181140	10.078309	10.259450	37
24	9.740742	9.921607	9.819135	10.180865	10.078393	10.259258	36
25	9.740934	9.921524	9.819410	10.180590	10.078476	10.259066	35
26	9.741125	9.921441	9.819684	10.180316	10.078559	10.258875	34
27	9.741316	9.921357	9.819959	10.180041	10.078693	10.258684	33
28	9.741507	9.921274	9.820234	10.179766	10.078720	10.258493	32
29	9.741699	9.921190	9.820508	10.179492	10.078810	10.258301	31
30	9.741889	9.921107	9.820783	10.179217	10.078893	10.258111	30
		Sine		Tangent		Secant	Minutes

56 Degrees

33 Degrees.

Minutes	Sine		Tangent		Secant		
30	9.741889	9.921107	9.820783	10.179217	10.078893	10.258111	30
31	9.742080	9.921023	9.821057	10.178943	10.078977	10.257920	29
32	9.742271	9.920939	9.821332	10.178668	10.079061	10 257729	28
33	9.742463	9.920855	9.821606	10.178394	10.079145	10.257538	27
34	9,742652	9 920772	9 821880	10.178120	10.079228	10.257348	26
35	9 742842	9.920688	9.822154	10,177846	10.079312	10.257158	25
36	9.743033	9.920604	9 822429	10.177571	10.079396	10.256967	24
37	9.743223	9.920520	9.822703	10.177297	10.079480	10.256777	23
38	9.743413	9.920436	9,822977	10.177023	10.079564	10.256587	22
39	9.743602	9 920352	9.823250	10.176750	10.079648	10.256398	21
40	9.743792	9.920268	9.823524	10.176476	10.079732	10.256208	20
41	9.743982	9.920184	9.823798	19.176202	10.079816	10.256018	19
42	9.744171	9.920099	9.824072	10.175928	10.079901	10.255829	18
43	9.744361	9.920015	9.824345	10 175655	10.079985	10.255639	17
44	9.744550	9.919931	9.824619	10.175381	10.080069	10.255450	16
45	9.744739	9.919846	9.824893	10.175107	10.080154	10.255261	15
46	9.744928	9.919762	9.825166	10.174834	10.080238	10.255072	14
47	9.745117	9.919677	9.825439	10.174561	10.080323	10.254883	13
48	9,745306	9.919593	9.825713	10.174287	10.080407	10.254694	12
49	9.745494	9.919508	9.825986	10.174014	10.080492	10.254506	11
50	9.745683	9.919424	9.826259	10.173741	10.080576	10.254317	10
51	9.745871	9.919339	9.826532	10.173468	10.080661	10.254129	9
52	9.746059	9.919254	9.826805	10.173195	10.080746	10.253940	8
53	9.746248	9.919169	9.827078	10.172922	10.080831	10.253752	7
54	9.746436	9.919084	9.827351	10.172649	10.080916	10.253564	6
55	9.746624	9.919000	9.827624	10.172376	10.081000	10.253376	5
56	9.746811	9 918915	9.827897	10.172103	10.081085	10.253189	4
57	9.746999	9.918830	9.828170	10.171830	10.081170	10.253001	3
58	9.747187	9.918744	9.828442	10.171558	10.081256	10.252813	2
59	9.747374	9.918659	9.828715	10.171285	10.081341	10.252626	1
60	9.747562	9.918574	9.828987	10.171013	10.081426	10.252438	0
		Sine		Tangent		Secant	Minutes

56 Degrees.

34 Degrees

Minutes	Sine		Tangent		Secant		
0	9.747562	9.918574	9.828987	10.171013	10.081426	10.252438	60
1	9.747749	9.918489	9.829260	10.170740	10.081511	10.252251	59
2	9.747936	9.918404	9.829532	10.170468	10.081596	10.252064	58
3	9.748123	9.918318	9.829805	10.170195	10.081682	10.251877	57
4	9.748310	9.918233	9.830077	10.169923	10.081767	10.251690	56
5	9.748497	9.918147	9.830349	10.169651	10.081853	10.251503	55
6	9.748683	9.918062	9.830621	10.169379	10.081938	10.251317	54
7	9.748870	9.917976	9.830893	10.169107	10.082024	10.251130	53
8	9.749056	9.917891	9.831165	10.168835	10.082109	10.250944	52
9	9.749242	9.917805	9.831437	10.168563	10.082195	10.250758	51
10	9.749429	9.917719	9.831709	10.168291	10.082281	10.250571	50
11	9.749615	9.917634	9.831981	10.168019	10.082366	10.250385	49
12	9.749801	9.917548	9.832253	10.167747	10.082452	10.250199	48
13	9.749987	9.917462	9.832525	10.167475	10.082538	10.250013	47
14	9.750172	9.917376	9.832796	10.167204	10.082624	10.249828	46
15	9.750358	9.917290	9.833068	10.166932	10.082710	10.249642	45
16	9.750543	9.917204	9.833339	10.166661	10.082796	10.249457	44
17	9.750729	9.917118	9.833611	10.166389	10.082882	10.249271	43
18	9.750914	9.917032	9.833882	10,166118	10.082968	10.249086	42
19	9.751099	9.916945	9.834154	10.165846	10.083055	10.248901	41
20	9.751284	9.916859	9.834425	10.165575	10.083141	10.248716	40
21	9.751469	9.916773	9.834696	10.165304	10.083227	10.248531	39
22	9.751654	9.916687	9.834967	10.165033	10.083313	10.248346	38
23	9.751838	9.916600	9.835238	10.164762	10.083400	10.248162	37
24	9.752023	9.916514	9.835509	10.164491	10.083486	10.247977	36
25	9.752207	9.916427	9.835780	10.164220	10.083573	10.247793	35
26	9.752392	9.916341	9.836051	10.163949	10.083659	10.247608	34
27	9.752576	9.916254	9.836322	10.163678	10.083746	10.247424	33
28	9.752760	9.916167	9.836593	10.163407	10.083833	10.247240	32
29	9.752944	9.916080	9.836864	10.163136	10.083920	10.247056	31
30	9.753128	9.915994	9.837134	10.162866	10.084006	10.246872	30
		Sine		Tangent		Secant	Minutes

55 Degrees

34 *Degrees.*

Minutes	Sine		Tangent		Secant		
30	9.753128	9.915994	9.837134	10.162866	10.084006	10.246872	30
31	9.753312	9.915907	9.837405	10.162595	10.084093	10.246688	29
32	9.753495	9.915820	9.837675	10.162325	10.084180	10.246505	28
33	9.753679	9.915733	9.837946	10.162054	10.084267	10.246321	27
34	9.753862	9.915646	9.838216	10.161784	10.084354	10.246138	26
35	9.754046	9.915559	9.838487	10.161513	10.084441	10.245954	25
36	9.754229	9.915472	9.838757	10.161243	10.084528	10.245771	24
37	9.754412	9.915385	9.839027	10.160973	10.084615	10.245588	23
38	9.754595	9.915297	9.839297	10.160703	10.084703	10.245405	22
39	9.754778	9.915210	9.839568	10.160432	10.084790	10.245222	21
40	9.754960	9.915123	9.839838	10.160162	10.084877	10.245040	20
41	9.755143	9.915035	9.840108	10.159892	10.084965	10.244857	19
42	9.755326	9.914948	9.840378	10.159622	10.085052	10.244674	18
43	9.755508	9.914860	9.840647	10.159353	10.085140	10.244492	17
44	9.755690	9.914773	9.840917	10.159083	10.085227	10.244310	16
45	9.755872	9.914685	9.841187	10.158813	10.085315	10.244128	15
46	9.756054	9.914598	9.841457	10.158543	10.085402	10.243946	14
47	9.756236	9.914510	9.841726	10.158274	10.085490	10.243764	13
48	9.756418	9.914422	9.841996	10.158004	10.085578	10.243582	12
49	9.756600	9.914334	9.842266	10.157734	10.085666	10.243400	11
50	9.756781	9.914246	9.842535	10.157465	10.085754	10.243219	10
51	9.756963	9.914158	9.842805	10.157195	10.085842	10.243037	9
52	9.757144	9.914070	9.843074	10.156926	10.085930	10.242856	8
53	9.757326	9.913982	9.843343	10.156657	10.086018	10.242674	7
54	9.757507	9.913894	9.843612	10.156388	10.086106	10.242493	6
55	9.757688	9.913806	9.843882	10.156118	10.086194	10.242312	5
56	9.757869	9.913718	9.844151	10.155849	10.086282	10.242131	4
57	9.758049	9.913630	9.844420	10.155580	10.086370	10.241951	3
58	9.758230	9.913541	9.844689	10.155311	10.086459	10.241770	2
59	9.758411	9.913453	9.844958	10.155042	10.086547	10.241589	1
60	9.758591	9.913364	9.845227	10.154773	10.086636	10.241409	0
		Sine		Tangent		Secant	Minutes

55 *Degrees.*

35 *Degrees*

Minutes	Sine		Tangent		Secant		
0	9.758591	9.913364	9.845227	10.154773	10.086636	10.241409	60
1	9.758772	9.913276	9.845496	10.154504	10.086724	10.241228	59
2	9.758952	9.913187	9.845764	10.154236	10.086813	10.241048	58
3	9.759132	9.913099	9.846033	10.153967	10.086901	10.240868	57
4	9.759312	9.913010	9.846302	10.153698	10.086990	10.240688	56
5	9.759492	9.912921	9.846570	10.153430	10.087079	10.240508	55
6	9.759672	9.912833	9.846839	10.153161	10.087167	10.240328	54
7	9.759851	9.912744	9.847107	10.152893	10.087256	10.240149	53
8	9.760031	9.912655	9.847376	10.152624	10.087345	10.239969	52
9	9.760211	9.912566	9.847644	10.152356	10.087434	10.239789	51
10	9.760390	9.912477	9.847913	10.152087	10 087523	10.239610	50
11	9.760569	9.912388	9.848181	10.151819	10.087612	10.239431	49
12	9.760748	9.912299	9.848449	10.151551	10.087701	10.239252	48
13	9.760926	9.912210	9.848717	10.151283	10.087790	10.239073	47
14	9.761106	9.912121	9.848985	10.151015	10.087879	10.238894	46
15	9.761285	9.912031	9.849254	10.150746	10.087969	10.238715	45
16	9.761464	9.911942	9.849522	10.150478	10.088050	10.238536	44
17	9.761642	9.911853	9.849790	10.150210	10.088147	10.238358	43
18	9.761821	9.911763	9.850057	10.149943	10.088237	10.238179	42
19	9.761999	9.911674	9.850325	10.149675	10.088326	10.238001	41
20	9.762177	9.911584	9.850592	10.149407	10.088416	10.23782[illegible]	40
21	9.762356	9.911495	9.850861	10.149139	10.088505	10.237644	39
22	9.762534	9.911405	9.851128	10.148872	10.088595	10.237466	38
23	9.762712	9.911315	9.851396	10.148604	10.088684	10.237288	37
24	9.762889	9.911226	9.851664	10.148336	10.088774	10.237111	36
25	9.763067	9.911136	9.851931	10.148069	10.088864	10.236933	35
26	9.763245	9.911046	9.852199	10.147801	10.088954	10.236755	34
27	9.763422	9.910956	9.852466	10.147534	10.089044	10.236578	33
28	9.763600	9.910866	9.852733	10.147267	10.089134	10.236400	32
29	9.763777	9.910776	9.853001	10.146999	10.089224	10.236223	31
30	9.763954	9.910686	9.853268	10.126732	10.089314	10.236046	30
		Sine		Tangent		Secant	Minutes

54 *Degrees*

35 Degrees.

Minutes	Sine		Tangent		Secant		
30	9.763954	9.910686	9.853268	10.146732	10.089314	10.236046	30
31	9.764131	9.910596	9.853535	10.146465	10.089404	10.235869	29
32	9.764308	9.910506	9.853802	10.146198	10.089494	10.235692	28
33	9.764485	9.910415	9.854069	10.145931	10.089585	10.235515	27
34	9.764662	9.910325	9.854336	10.145664	10.089675	10.235338	26
35	9.764838	9.910235	9.854603	10.145397	10.089765	10.235162	25
36	9.765015	9.910144	9.854870	10.145130	10.089856	10.234985	24
37	9.765191	9.910054	9.855137	10.144863	10.089946	10.234809	23
38	9.765367	9.909963	9.855404	10.144596	10.090037	10.234633	22
39	9.765544	9.909873	9.855671	10.144329	10.090127	10.234456	21
40	9.765720	9.909782	9.855938	10.144062	10.090218	10.234280	20
41	9.765896	9.909691	9.856204	10.143796	10.090309	10.234104	19
42	9.766071	9.909601	9.856471	10.143529	10.090399	10.233929	18
43	9.766247	9.909510	9.856737	10.143263	10.090490	10.233753	17
44	9.766423	9.909419	9.857004	10.142996	10.090581	10.233577	16
45	9.766598	9.909328	9.857270	10.142730	10.090672	10.233402	15
46	9.766774	9.909237	9.857537	10.142463	10.090763	10.233226	14
47	9.766949	9.909146	9.857803	10.142197	10.090854	10.233051	13
48	9.767124	9.909055	9.858069	10.141931	10.090945	10.232876	12
49	9.767299	9.908964	9.858336	10.141664	10.091036	10.232700	11
50	9.767475	9.908873	9.858602	10.144398	10.091127	10.232525	10
51	9.767549	9.908781	9.858868	10.141132	10.091219	10.232351	9
52	9.767824	9.908691	9.859134	10.140866	10.091310	10.232176	8
53	9.767999	9.908599	9.859400	10.140600	10.091401	10.232001	7
54	9.768173	9.908507	9.859666	10.140334	10.091493	10.231827	6
55	9.768348	9.908416	9.859932	10.140068	10.091584	10.231652	5
56	9.768522	9.908324	9.860198	10.139802	10.091676	10.231478	4
57	9.768697	9.908233	9.860464	10.139536	10.091767	10.231303	3
58	9.768871	9.908141	9.860730	10.139270	10.091859	10.231129	2
59	9.769045	9.908049	9.860995	10.139005	10.091951	10.230955	1
60	9.769219	9.907958	9.861261	10.138739	10.092042	10.230781	0
		Sine		Tangent		Secant	Minutes

54 Degrees.

36 Degrees

Minutes	Sine		Tangent		Secant		
0	9.769219	9.907958	9.861261	10.138739	10.092042	10.230781	60
1	9.769392	9.907866	9.861527	10.138473	10.092134	10.230608	59
2	9.769566	9.907774	9.861792	10.138208	10.092226	10.230434	58
3	9.769740	9.907682	9.862058	10.137942	10.092318	10.230260	57
4	9.769913	9.907590	9.862323	10.137677	10.092410	10.230087	56
5	9.770087	9.907498	9.862589	10.137411	10.092502	10.229913	55
6	9.770260	9.907406	9.862854	10.137146	10.092594	10.229740	54
7	9.770433	9.907314	9.863119	10.136881	10.092686	10.229567	53
8	9.770606	9.907222	9.863385	10.136615	10.092778	10.229394	52
9	9.770779	9.907129	9.863650	10.136350	10.092871	10.229221	51
10	9.770952	9.907037	9.863915	10.136085	10.092963	10.229048	50
11	9.771125	9.906945	9.864180	10.135820	10.093055	10.228875	49
12	9.771298	9.906852	9.864445	10.135555	10.093148	10.228702	48
13	9.771470	9.906760	9.864710	10.135289	10.093240	10.228530	47
14	9.771643	9.906667	9.864975	10.135025	10.093333	10.228357	46
15	9.771815	9.906574	9.865240	10.134760	10.093426	10.228185	45
16	9.771987	9.906482	9.865505	10.134495	10.093518	10.228013	44
17	9.772159	9.906389	9.865770	10.134230	10.093611	10.227841	43
18	9.772331	9.906296	9.866035	10.133965	10.093704	10.227669	42
19	9.772503	9.906204	9.866300	10.133700	10.093796	10.227497	41
20	9.772675	9.906111	9.866564	10.133436	10.093889	10.227325	40
21	9.772847	9.906018	9.866829	10.133171	10.093982	10.227153	39
22	9.773018	9.905925	9.867094	10.132906	10.094075	10.226982	38
23	9.773190	9.905832	9.867358	10.132642	10.094168	10.226810	37
24	9.773361	9.905739	9.867623	10.132377	10.094261	10.226639	36
25	9.773533	9.905645	9.867887	10.132113	10.094355	10.226467	35
26	9.773704	9.905552	9.868152	10.131848	10.094448	10.226296	34
27	9.773875	9.905459	9.868416	10.131584	10.094541	10.226125	33
28	9.774046	9.905366	9.868680	10.131320	10.094634	10.225954	32
29	9.774217	9.905272	9.868945	10.131055	10.094728	10.225783	31
30	9.774388	9.905179	9.869209	10.130791	10.094821	10.225612	30
		Sine		Tangent		Secant	Minutes

53 Degrees

36 *Degrees.*

Minutes	Sine		Tangent		Secant		
30	9.774388	9.905179	9.869209	10.130791	10.094821	10.225612	30
31	9.774558	9.905085	9.869473	10.130527	10.094915	10.225442	29
32	9.774729	9.904992	9.869737	10.130263	10.095008	10.225271	28
33	9.774899	9.904898	9.870001	10.129999	10.095102	10.225101	27
34	9.775070	9.904804	9.870265	10.129735	10.095196	10.224930	26
35	9.775240	9.904711	9.870529	10.129471	10.095289	10.224760	25
36	9.775410	9.904617	9.870793	10.129207	10.095383	10.224590	24
37	9.775580	9.904523	9.871057	10.128943	10.095477	10.224420	23
38	9.775750	9.904429	9.871321	10.128679	10.095571	10.224250	22
39	9.775920	9.904335	9.871585	10.128415	10.095665	10.224080	21
40	9.776090	9.904241	9.871849	10.128151	10.095759	10.223910	20
41	9.776259	9.904147	9.872112	10.127888	10.095853	10.223741	19
42	9.776429	9.904053	9.872376	10.127624	10.095947	10.223571	18
43	9.776598	9.903959	9.872640	10.127360	10.096041	10.223402	17
44	9.776768	9.903864	9.872903	10.127097	10.096136	10.223232	16
45	9.776937	9.903770	9.873167	10.126833	10.096230	10.223063	15
46	9.777106	9.903676	9.873430	10.126570	10.096324	10.222894	14
47	9.777275	9.903581	9.873694	10.126306	10.096419	10.222725	13
48	9.777444	9.903487	9.873957	10.126043	10.096513	10.222556	12
49	9.777613	9.903392	9.874220	10.125780	10.096608	10.222387	11
50	9.777781	9.903298	9.874484	10.125516	10.096702	10.222219	10
51	9.777950	9.903203	9.874747	10.125253	10.096797	10.222050	9
52	9.778119	9.903108	9.875010	10.124990	10.096892	10.221881	8
53	9.778287	9.903014	9.875273	10.124727	10.096986	10.221713	7
54	9.778455	9.902919	9.875536	10.124464	10.097081	10.221545	6
55	9.778623	9.902824	9.875800	10.124200	10.097176	10.221377	5
56	9.778792	9.902729	9.876063	10.123937	10.097271	10.221208	4
57	9.778960	9.902634	9.876326	10.123674	10.097366	10.221040	3
58	9.779128	9.902539	9.876589	10.123411	10.097461	10.220872	2
59	9.779295	9.902444	9.876851	10.123149	10.097556	10.220705	1
60	9.779463	9.902349	9.877114	10.122886	10.097651	10.220537	0
		Sine		Tangent		Secant	Minutes

53 *Degrees.*

37 *Degrees.*

Minutes	Sine		Tangent		Secant		
0	9.779463	9.902349	9.877114	10.122886	10.097651	10.220537	60
1	9.779631	9.902253	9.877377	10.122623	10.097747	10.220369	59
2	9.779798	9.902158	9.877640	10.122360	10.097842	10.220202	58
3	9.779965	9.902063	9.877903	10.122097	10.097937	10.220035	57
4	9.780133	9.901967	9.878165	10.121835	10.098033	10.219867	56
5	9.780300	9.901872	9.878428	10.121572	10.098128	10.219700	55
6	9.780467	9.901776	9.878691	10.121309	10.098224	10.219533	54
7	9.780634	9.901681	9.878953	10.121047	10.098319	10.219366	53
8	9.780801	9.901585	9.879216	10.120784	10.098415	10.219199	52
9	9.780968	9.901489	9.879478	10.120522	10.098511	10.219032	51
10	9.781134	9.901394	9.879741	10.120259	10.098606	10.218866	50
11	9,781301	9.901298	9.880003	10.119997	10.098702	10.218699	49
12	9.781467	9.901202	9.880265	10.119735	10.098798	10.218533	48
13	9.781634	9.901106	9.880528	10.119472	10.098894	10.218366	47
14	9.781800	9.901010	9.880790	10.119210	10.098990	10.218200	46
15	9.781966	9.900914	9.881052	10.118948	10.099086	10.218034	45
16	9.782132	9.900818	9.881314	10.118686	10.099182	10.217868	44
17	9.782298	9.900721	9.881576	10.118424	10.099279	10.217702	43
18	9.782464	9.900626	9.881839	10.118161	10.099374	10.217536	42
19	9.782630	9.900529	9.882101	10.117899	10.099471	10.217370	41
20	9.782796	9.900433	9.882363	10.117637	10.099567	10.217204	40
21	9.782961	9.900337	9.882625	10.117375	10.099663	10:217039	39
22	9.783127	9.900240	9.882887	10.117113	10.099760	10.216873	38
23	9.783292	9.900144	9.883148	10.116852	10.099856	10.216708	37
24	9,783457	9.900047	9.883410	10.116590	10.099953	10.216543	36
25	9.783623	9.899951	9.883672	10.116328	10.100049	10.216377	35
26	9.783788	9.899854	9.883934	10.116066	10.100146	10.216212	34
27	9.783953	9.899757	9.884196	10.115804	10.100243	10.216047	33
28	9.784118	9.899660	9.884457	10.115543	10.100340	10.215882	32
29	9.784282	9.899564	9.884719	10.115281	10.100436	10.215718	31
30	9.784447	9.899467	9.884980	10.115020	10.100533	10.215553	30
		Sine		Tangent		Secant	Minutes

52 *Degrees.*

37 Degrees.

Minutes	Sine		Tangent		Secant		
30	9.784447	9.899467	9.884980	10.115020	10.100533	10.215553	30
31	9.784612	9.899370	9.885242	10.114758	10.100630	10.215388	29
32	9.784776	9.899273	9.885503	10.114497	10.100727	10.215224	28
33	9.784941	9.899176	9.885765	10.114235	10.100824	10.215059	27
34	9.785105	9.899078	9.886026	10.113974	10.100922	10.214895	26
35	9.785269	9.898981	9.886288	10.113712	10.101019	10.214731	25
36	9.785433	9.898884	9.886549	10.113451	10.101116	10.214567	24
37	9.785597	9.898787	9.886810	10.113190	10.101213	10.214403	23
38	9.785761	9.898689	9.887072	10.1129 8	10.101311	10.214239	22
39	9.785925	9.898592	9.887333	10.112667	10.101408	10.214075	21
40	9.786089	9.898494	9.887594	10.112406	10.101506	10.213911	20
41	9.786252	9.898397	9.887855	10.112145	10.101603	10.213748	19
42	9.786416	9.898299	9.888116	10.111884	10.101700	10.213584	18
43	9.786579	9.898201	9.888377	10.111623	10.101798	10.213421	17
44	9.786742	9.898104	9.888639	10.111361	10.101890	10.213258	16
45	9.786906	9.898006	9.888900	10.111100	10.101994	10.213094	15
46	9.787069	9.897908	9.889160	10.110840	10.102092	10.212931	14
47	9.787232	9.897810	9.889421	10.110579	10.102190	10.212768	13
48	9.787395	9.897712	9.889682	10.110318	10.102288	10.212605	12
49	9.787557	9.897614	9.889943	10.110057	10.102386	10.212443	11
50	9.787720	9.897516	9.890204	10.109796	10.102484	10.212280	10
51	9.787883	9.897418	9.890465	10.109535	10.102582	10.212117	9
52	9.788045	9.897320	9.890725	10.109275	10.102680	10.211955	8
53	9.788208	9.897222	9.890986	10.109014	10.102778	10.211792	7
54	9.788370	9.897123	9.891247	10.108753	10.102877	10.211630	6
55	9.788532	9.897025	9.891507	10.108493	10.102975	10.211468	5
56	9.788694	9.896926	9.891768	10.108232	10.103074	10.211306	4
57	9.788856	9.896828	9.892028	10.107972	10.103172	10.211144	3
58	9.789018	9.896729	9.892289	10.107711	10.103271	10.210982	2
59	9.789180	9.896631	9.892549	10.107451	10.103369	10.210820	1
60	9.789342	9.896532	9.892810	10.107190	10.103468	10.210658	0
		Sine		Tangent		Secant	Minutes

52 Degrees.

38 *Degrees.*

Minutes	Sine		Tangent		Secant		
0	9.789342	9.896532	9.892810	10.107190	10.103468	10.210658	60
1	9.789504	9.896433	9.893070	10.106930	10.103567	10.210496	59
2	9.789665	9.896335	9.893331	10.106669	10.103665	10.210335	58
3	9.789827	9.896236	9.893591	10.106409	10.103764	10.210173	57
4	9.789988	9.896137	9.893851	10.106149	10.103863	10.210012	56
5	9.790149	9.896038	9.894111	10.105889	10.103962	10.209851	55
6	9.790310	9.895939	9.894371	10.105629	10.104061	10.209690	54
7	9.790471	9.895840	9.894632	10.105368	10.104160	10.209529	53
8	9.790632	9.895741	9.894892	10.105108	10.104259	10.209368	52
9	9.790793	9.895641	9.895152	10.104848	10.104359	10.209207	51
10	9.790954	9.895542	9.895412	10.104588	10.104458	10.209046	50
11	9.791115	9.895443	9.895672	10.104328	10.104557	10.208885	49
12	9.791275	9.895343	9.895932	10.104068	10.104657	10.208725	48
13	9.791436	9.895244	9.896192	10.103808	10.104756	10.208564	47
14	9.791596	9.895144	9.896452	10.103548	10.104856	10.208404	46
15	9.791757	9.895045	9.896712	10.103288	10.104955	10.208243	45
16	9.791917	9.894945	9.896971	10.103029	10.105055	10.208083	44
17	9.792077	9.894846	9.897231	10.102769	10.105154	10.207923	43
18	9.792237	9.894746	9.897491	10.102509	10.105254	10.207763	42
19	9.792397	9.894646	9.897751	10.102249	10.105354	10.207603	41
20	9.792557	9.894546	9.898010	10.101990	10.105454	10.207443	40
21	9.792716	9.894446	9.898270	10.101730	10.105554	10.207284	39
22	9.792876	9.894346	9.898530	10.101470	10.105654	10.207124	38
23	9.793035	9.894246	9.898789	10.101211	10.105754	10.206965	37
24	9.793195	9.894146	9.899049	10.100951	10.105854	10.206805	36
25	9.793354	9.894046	9.899308	10.100692	10.105954	10.206646	35
26	9.793513	9.893946	9.899568	10.100432	10.106054	10.206487	34
27	9.793673	9.893846	9.899827	10.100173	10.106154	10.206327	33
28	9.793832	9.893745	9.900086	10.099914	10.106255	10.206168	32
29	9.793991	9.893645	9.900346	10.099654	10.106355	10.206009	31
30	9.794150	9.893544	9.900605	10.099395	10.106456	10.205850	30
		Sine		Tangent		Secant	Minutes

51 *Degrees.*

38 Degrees.

Minutes	Sine		Tangent		Secant		
30	9.794150	9.893544	9.900605	10.099395	10.106456	10.205850	30
31	9.794308	9.893444	9.900864	10.099136	10.106556	10.205692	29
32	9.794467	9.893343	9.901124	10.098876	10.106657	10.205533	28
33	9.79462	9.893243	9.901383	10.098617	10.106757	10.205374	27
34	9.794784	9.893142	9.901642	10.098358	10.106858	10.205216	26
35	9.794942	9.893041	9.901901	10.098099	10.106959	10.205058	25
36	9.795101	9.892940	9.902160	10.097840	10.107060	10.204899	24
37	9.795259	9.892839	9.902419	10.097581	10.107161	10.204741	23
38	9.795417	9.892738	9.902679	10.097321	10.107262	10.204583	22
39	9.795575	9.892637	9.902938	10.097062	10.107363	10.204425	21
40	9.795733	9.892536	9.903197	10.096803	10.107464	10.204267	20
41	9.795891	9.892435	9.903455	10.096545	10.107565	10.204109	19
42	9.796049	9.892334	9.903714	10.096286	10.107666	10.203951	18
43	9.796206	9.892233	9.903973	10.096027	10.107767	10.203794	17
44	9.796364	9.892132	9.904232	10.095768	10.107868	10.203636	16
45	9.796521	9.892030	9.904491	10.095509	10.107970	10.203479	15
46	9.796679	9.891929	9.904750	10.095250	10.108071	10.203321	14
47	9.796836	9.891827	9.905008	10.094992	10.108173	10.203164	13
48	9.796993	9.891726	9.905267	10.094733	10.108274	10.203007	12
49	9.797150	9.891624	9.905526	10.094474	10.108376	10.202850	11
5	9.797307	9.891523	9.905784	10.094216	10.108477	10.202693	10
51	9.797464	9.891421	9.906043	10.093957	10.108579	10.202536	9
52	9.797621	9.891319	9.906302	10.093698	10.108681	10.202379	8
53	9.797777	9.891217	9.906560	10.093440	10.108783	10.202223	7
54	9.797934	9.891115	9.906819	10.093181	10.108885	10.202066	6
55	9.798091	9.891013	9.907077	10.092923	10.108987	10.201909	5
56	9.798247	9.890911	9.907336	10.092664	10.109089	10.201753	4
57	9.798403	9.890809	9.907594	10.092406	10.109191	10.201 97	3
58	9.798560	9.890707	9.907852	10.092148	10.109293	10.201440	2
59	9.798716	9.890605	9.908111	10.091889	10.109395	10.201284	1
6	9.798872	9.890503	9.908369	10.091631	10.109497	10.201128	0
		Sine		Tangent		Secant	Minutes

51 Degrees

39 Degrees

Minutes	Sine		Tangent		Secant		
0	9.798872	9.890503	9.908369	10.091631	10.109497	10.201128	60
1	9.799028	9.890400	9.9 8627	10.091373	10.109600	10.200972	59
2	9.799184	9.890298	9.908886	10.091114	10.109702	10.200816	58
3	9.799339	9.890195	9.909144	10.090856	10.109805	10.200661	57
4	9.799495	.890093	9.909402	10.090598	10.109907	10.20050	56
5	9.799651	9.889990	9.909660	10.090340	10.11001	10.200349	55
6	9.799806	9.889888	9.909918	10.090082	10.110112	10.200194	54
7	9.799962	9.889785	9.910177	10.089823	10.110215	10.200038	53
8	9.800117	9.889682	9.910435	10.089565	10.110318	10.199883	52
9	9.8 0272	9 889579	9.910693	10.089307	10.110421	10.199728	51
10	9.800427	9.889476	9.911951	10.089049	10.110524	10.199573	50
11	9.800582	9.889374	9.911209	10.088791	10.110626	10.199418	49
12	9.800737	9.889271	9.911467	10.088533	10.110729	10 199263	48
13	9.800892	9.889167	9.911724	10.088276	10.110833	10.199108	47
14	9.801047	9.889064	9.911982	10.088018	10.110936	10.198953	46
15	9.801201	9.888961	9.912240	10.087760	10.111039	10.198799	45
16	9.801356	9.888858	9.912498	10.087500	10.111142	10.198644	44
17	9.801511	9.888755	9.912756	10.087244	10.111245	10.198489	43
18	9.801665	9.888651	9.913014	10.086986	10.111349	10.198335	42
19	9.801819	9.888548	9.913271	10.086729	10.111452	10.198181	41
20	9.801973	9.888444	9.913529	10.086471	10.111556	10.198027	40
21	9.802128	9.888341	9 913787	10.086213	10.111659	10.197872	39
22	9.802282	9.888237	9.914044	10.085956	10.111763	10.197718	38
23	9.802435	9.888133	9.914302	10.085698	10.111867	10.197565	37
24	9.802589	9.888030	9.914560	10.085440	10.111970	10.197411	36
25	9.802743	9.887926	9.914817	0.085183	10.112074	10.197257	35
26	9.802897	9.887822	9.915075	10.084925	10.112178	10.197103	34
27	9.803050	9.887718	9 915332	10.084668	10.112282	10.196950	33
28	9.803204	9.887614	9.915590	10.084410	10.112386	10.196796	32
29	9.803357	9.887510	9.915847	10.084153	10.112490	10.196643	31
30	9.803510	9.887406	9.916104	10.083896	10.112594	10.196490	30
		Sine		Tangent		Secant	Minutes

50 Degrees

39 Degrees

Minutes	Sine		Tangent		Secant		
30	9.803510	9.887406	9.916104	10.083896	10.112594	10.196490	30
31	9.803664	9.887302	9.916362	10.083638	10.112698	10.196336	29
32	9.803817	9.887198	9.916619	10.083381	10.112802	10.196183	28
33	9.803970	9.887093	9.916876	10.083124	10.112907	10.196030	27
34	9.804123	9.886989	9.917134	10.082866	10.113011	10.195877	26
35	9.804276	9.886885	9.917391	10.082609	10.113115	10.195724	25
36	9.804428	9.886780	9.917648	10.082352	10.113220	10.195572	24
37	9.804581	9.886676	9.917905	10.082095	10.113324	10.195419	23
38	9.804734	9.886571	9.918163	10.081837	10.113429	10.195266	22
39	9.804886	9.886466	9.918420	10.081580	10.113534	10.195114	21
40	9.805038	9.886362	9.918677	10.081323	10.113638	10.194962	20
41	9.805191	9.886257	9.918934	10.081066	10.113743	10.194809	19
42	9.805343	9.886152	9.919191	10.080809	10.113848	10.194657	18
43	9.805495	9.886047	9.919448	10.080552	10.113953	10.194505	17
44	9.805647	9.885942	9.919705	10.080295	10.114058	10.194353	16
45	9.805799	9.885837	9.919962	10.080038	10.114163	10.194201	15
46	9.805951	9.885732	9.920219	10.079781	10.114268	10.194049	14
47	9.806103	9.885627	9.920476	10.079524	10.114373	10.193897	13
48	9.806254	9.885521	9.920733	10.079267	10.114479	10.193746	12
49	9.806406	9.885416	9.920990	10.079010	10.114584	10.193594	11
50	9.806557	9.885311	9.921247	10.078753	10.114689	10.193443	10
51	9.806709	9.885205	9.921503	10.078497	10.114795	10.193291	9
52	9.806860	9.885100	9.921760	10.078240	10.114900	10.193140	8
53	9.807011	9.884994	9.922017	10.077983	10.115006	10.192989	7
54	9.807163	9.884889	9.922274	10.077726	10.115111	10.192837	6
55	9.807314	9.884783	9.922530	10.077470	10.115217	10.192686	5
56	9.807465	9.884677	9.922787	10.077213	10.115323	10.192535	4
57	9.807615	9.884572	9.923044	10.076956	10.115428	10.192385	3
58	9.807766	9.884466	9.923300	10.076700	10.115534	10.192234	2
59	9.807917	9.884360	9.923557	10.076443	10.115640	10.192083	1
60	9.808067	9.884254	9.923813	10.076187	10.115746	10.191933	0
		Sine		Tangent		Secant	Minutes

50 Degrees.

40 *Degrees*

Minutes	Sine		Tangent		Secant		
0	9.808067	9.884254	9.923813	10.076187	10.115746	10.191932	60
1	9.808218	9.884148	9.924070	10.075930	10.115852	10.191782	59
2	9.808368	9.884042	9.924327	10.075673	10.115958	10.191632	58
3	9.808519	9.883936	9.924583	10.075417	10.116064	10.191481	57
4	9.808669	9.883829	9.924840	10.075160	10.116171	10.191331	56
5	9.808819	9.883723	9.925096	10.074904	10.116277	10.191181	55
6	9.808969	9.883617	9.925352	10.074648	10.116383	10.191030	54
7	9.809119	9.883510	9.925609	10.074391	10.116490	10.190881	53
8	9.809269	9.883404	9.925865	10.074135	10.116596	10.190731	52
9	9.809419	9.883297	9.926121	10.073879	10.116703	10.190581	51
10	9.809569	9.883191	9.926378	10.073622	10.116809	10.190431	50
11	9.809718	9.883084	9.926634	10.073366	10.116916	10.190282	49
12	9.809868	9.882977	9.926890	10.073110	10.117023	10.190132	48
13	9.810017	9.882871	9.927147	10.072853	10.117129	10.189983	47
14	9.810167	9.882764	9.927403	10.072597	10.117236	10.189833	46
15	9.810316	9.882657	9.927659	10.072341	10.117343	10.189684	45
16	9.810465	9.882550	9.927915	10.072085	10.117450	10.189535	44
17	9.810614	9.882443	9.928171	10.071829	10.117557	10.189386	43
18	9.810763	9.882336	9.928427	10.071573	10.117664	10.189237	42
19	9.810912	9.882228	9.928683	10.071317	10.117772	10.189088	41
20	9.811061	9.882121	9.928940	10.071060	10.117879	10.188939	40
21	9.811210	9.881014	9.929196	10.070804	10.117986	10.188790	39
22	9.811358	9.881907	9.929452	10.070548	10.118093	10.188642	38
23	9.811507	9.881799	9.929708	10.070292	10.118201	10.188493	37
24	9.811655	9.881692	9.929964	10.070036	10.118308	10.188345	36
25	9.811804	9.881584	9.930219	10.069781	10.118416	10.188196	35
26	9.811952	9.881477	9.930475	10.069525	10.118523	10.188048	34
27	9.812100	9.881369	9.930731	10.069269	10.118631	10.187900	33
28	9.812248	9.881261	9.930987	10.069013	10.118739	10.187752	32
29	9.812396	9.881153	9.931243	10.068757	10.118847	10.187603	31
30	9.812544	9.881045	9.931499	10.068501	10.118955	10.187456	30
		Sine		Tangen		Secant	Minutes

49 *Degrees.*

40 Degrees.

Minutes	Sine		Tangent		Secant		
30	9.812544	9.881045	9.931499	10.068501	10.118955	10.187456	30
31	9.812692	9.880938	9.931755	10.068245	10.119062	10.187308	29
32	9.812840	9.880830	9.932010	10.067990	10.119170	10.187160	28
33	9.812988	9.880721	9.932266	10.067734	10.119279	10.187012	27
34	9.813135	9.880613	9.932522	10.067478	10.119387	10.186865	26
35	9.813283	9.880505	9.932778	10.067222	10.119495	10.186717	25
36	9.813420	9.880397	9.933033	10.066967	10.119603	10.186570	24
37	9.813578	9.880289	9.933289	10.066711	10.119711	10.186422	23
38	9.813725	9.880180	9.933545	10.066455	10.119820	10.186275	22
39	9.813872	9.880072	9.933800	10.066200	10.119928	10.186128	21
40	9.814019	9.879963	9.934056	10.065944	10.120037	10.185981	20
41	9,814166	9.879855	9.934311	10.065689	10.120145	10.185834	19
42	9-814313	9.879746	9.934567	10.065433	10.120254	10.185687	18
43	9.814460	9.879637	9.934823	10.065177	10.120363	10.185540	17
44	9.814607	9.879529	9.935078	10.064922	10.120471	10.185393	16
45	9.814753	9.879420	9.935333	10.064667	10.120580	10.185247	15
46	9.814900	9.879311	9.935589	10.064411	10.120689	10.185100	14
47	9.815046	9.879202	9.935844	10.064156	10.120798	10.184954	13
48	9.815193	9.879093	9.936100	10.063900	10.120907	10.184807	12
49	9.815339	9.878984	9.936355	10.063645	10.121016	10.184661	11
50	9.815485	9.878875	9.936610	10.063390	10.121125	10.184515	10
51	9.815631	9.878766	9.936866	10.063134	10.121234	10:184369	9
52	9-815778	9.878656	9.937121	10.062879	10.121344	10.184222	8
53	9.815923	9.878547	9.937376	10.062624	10.121453	10.184077	7
54	9,816069	9.878438	9.937632	10.062368	10.121562	10.183931	6
55	9.816215	9.878328	9.937887	10.062113	10.121672	10.183785	5
56	9.816361	9.878219	9.938142	10.061858	10.121781	10.183639	4
57	9.816507	9.878109	9.938397	10·061603	10.121891	10.183493	3
58	9.816652	9.877999	9.938653	10.061347	10.122001	10.183348	2
59	9.816797	9.877890	9.938908	10.061092	10.122110	10.183203	1
60	9.816943	9.877780	9.939163	10.060837	10.122220	10.183057	0
		Sine		Tangent		Secant	Minutes

49 Degrees.

41 *Degrees,*

Minutes	Sine		Tangent		Secant		
0	9.816943	9.877780	9.939163	10.060837	10.122220	10.183057	60
1	9.817088	9.877670	9.939418	10.060582	10.122330	10.182912	59
2	9.817233	9.877560	9.939673	10.060327	10.122440	10.182767	58
3	9.817378	9.877450	9.9399 8	10.060072	10.122550	10.182022	57
4	9.817523	9.877340	9.940183	10.059817	10.122660	10.182477	56
5	9.817668	9.877230	9.940438	10.059562	10.122770	10.182332	55
6	9.817813	9.877120	9.940694	10.059306	10 122880	10.182187	54
7	9.817958	9.877020	9.940949	10.05905	10.122990	10.182042	53
8	9.818103	9.876899	9.941204	10.058796	10.123101	10.181897	52
9	9.818247	9.876789	9.941458	10.058542	10.123211	10.181753	51
10	9.818392	9.876678	9.941713	10.058287	10.123322	10.181608	50
11	9.818536	9.876568	9.941968	10.058032	10.123432	10.181464	49
12	9.818681	9.876457	9.942223	10.057777	10.123543	10.181319	48
13	9.818825	9.876347	9.942478	10.057522	10.123653	10.181175	47
14	9.818969	9.876236	9.942733	10.057267	10.123764	10.181031	46
15	9.819113	9.876125	9.942988	10.057012	10.123875	10.180887	45
16	9.819257	9.876014	9.943243	10.056757	10.123986	10.180743	44
17	9.819401	9.875904	9.943498	10.056502	10.124096	10.180599	43
18	9.819545	9.875793	9.943752	10.056248	10.124207	10.180455	42
19	9.819689	9.875682	9.944007	10.055993	10.124318	10.180311	41
20	9.819832	9.875571	9.944262	10.055738	10.124429	10.180168	40
21	9.819976	9.875459	9.944517	10.055483	10.124541	10.180024	39
22	9.820120	9.875348	9.944771	10.055229	10.124652	10.179880	38
23	9.820263	9.875237	9.945026	10.054974	10.124763	10.179737	37
24	9.820406	9.875126	9.945281	10.054719	10.124874	10.179594	36
25	9.820550	9.875014	9.945535	10.054465	10.124986	10.179450	35
26	9.820693	9.874903	9.945790	10.054210	10.125097	10.179307	34
27	9.820836	9.874791	9.946045	10.053955	10.129209	10.179164	33
28	9.820979	9.874679	9.946299	10.053701	10.125321	10.179021	32
29	9.821122	9.874568	9.946554	10.053446	10.125432	10.178878	31
30	9.821265	9.874456	9.946808	10.053192	10.125544	10.178735	30
		Sine		Tangent		Secant	Minutes

48 *Degrees.*

41 *Degrees.*

Minutes	Sine		Tangent		Secant		
30	9.821265	9.874456	9.946808	10.053192	10.125544	10.178735	30
31	9.821407	9.874344	9.947063	10.052937	10.125656	10.178593	29
32	9.821550	9.874232	9.947317	10.052683	10.125768	10.178450	28
33	9.821693	9.874120	9.947572	10.052428	10.125870	10.178307	27
34	9.821835	9.874008	9.947826	10.052174	10.125992	10.178165	26
35	9.821977	9.873896	9.948081	10.051919	10.126104	10.178023	25
36	9.822120	9.873784	9.948335	10.051665	10.126216	10.177880	24
37	9.822262	9.873672	9.948590	10.051410	10.126328	10.177738	23
38	9.822404	9.873560	9.948844	10.051155	10.126440	10.177596	22
39	9.822546	9.873448	9.949099	10.050901	10.126552	10.177454	21
40	9.822688	9.873335	9.949353	10.050647	10.126665	10.177312	20
41	9.822830	9.873223	9.949607	10.050393	10.126777	10.177170	19
42	9.822972	9.873110	9.949862	10.050138	10.126890	10.177028	18
43	9.823114	9.872998	9.950116	10.049884	10.127002	10.176886	17
44	9.823255	9.872885	9.950370	10.049630	10.127115	10.176745	16
45	9.823397	9.872772	9.950625	10.049375	10.127228	10.176603	15
46	9.823539	9.872659	9.950879	10.049121	10.127341	10.176461	14
47	9.823680	9.872547	9.951133	10.048867	10.127453	10.176320	13
48	9.823821	9.872434	9.951388	10.048612	10.127566	10.176179	12
49	9.823963	9.872321	9.951642	10.048358	10.127679	10.176037	11
50	9.824104	9.872208	9.951896	10.048104	10.127792	10.175896	10
51	9.824245	9.872094	9.952150	10.047850	10.127906	10.175755	9
52	9.824386	9.871981	9.952404	10.047596	10.128019	10.175614	8
53	9.824537	9.871868	9.952659	10.047341	10.128132	10.175473	7
54	9.824668	9.871755	9.952913	10.047087	10.128245	10.175332	6
55	9.824808	9.871641	9.953167	10.046833	10.128359	10.175192	5
56	9.824949	9.871528	9.953421	10.046579	10.128472	10.175051	4
57	9.825090	9.871414	9.953675	10.046325	10.128586	10.174910	3
58	9.825230	9.871301	9.953929	10.046071	10.128699	10.174770	2
59	9.825370	9.871187	9.954183	10.045817	10.128813	10.174630	1
60	9.825511	9.871073	9.954437	10.045563	10.128927	10.174489	0
		Sine		Tangent		Secant	Minutes

48 *Degrees.*

42 *Degrees.*

Minutes	Sine		Tangent		Secant		
0	9.825511	9.871073	9.954437	10.045563	10.128927	10.174489	60
1	9.825651	9.870960	9.954691	10.045309	10.129040	10.174349	59
2	9.825791	9.870846	9.954945	10.045055	10.129154	10.174209	58
3	9.825931	9.870732	9.955199	10.044801	10.129268	10.174069	57
4	9.826071	9.870618	9.955453	10.044547	10.129382	10.173929	56
5	9.826211	9.870504	9.955707	10.044293	10.129496	10.173789	55
6	9.826351	9.870390	9.955961	10.044039	10.129610	10.173649	54
7	9.826491	9.870276	9.956215	10.043785	10.129724	10.173509	53
8	9.826631	9.870161	9.956469	10.043531	10.129839	10.173369	52
9	9.826770	9.870047	9.956723	10.043277	10.129953	10.173230	51
10	9.826910	9.869933	9.956977	10.043023	10.130067	10.173090	50
11	9.827049	9.869818	9.957231	10.042769	10.130182	10.172951	49
12	9.827189	9.869704	9.957485	10.042515	10.130296	10.172811	48
13	9.827328	9.869589	9.957739	10.042261	10.130411	10.172672	47
14	9.827467	9.869474	9.957993	10.042007	10.130526	10.172533	46
15	9.827606	9.869360	9.958246	10.041754	10.130640	10.172394	45
16	9.827745	9.869245	9.958500	10.041500	10.130755	10.172255	44
17	9.827884	9.869130	9.958754	10.041246	10.130870	10.172116	43
18	9.828023	9.869015	9.959008	10.040992	10.130985	10.171977	42
19	9.828162	9.868900	9.959262	10.040738	10.131100	10.171838	41
20	9.828301	9.868785	9.959515	10.040485	10.131215	10.171699	40
21	9.828439	9.868670	9.959769	10.040231	10.131330	10.171561	39
22	9.828578	9.868555	9.960023	10.039977	10.131445	10.171422	38
23	9.828716	9.868440	9.960277	10.039723	10.131560	10.171284	37
24	9.828855	9.868324	9.960530	10.039470	10.131676	10.171145	36
25	9.828993	9.868209	9.960784	10.039216	10.131791	10.171007	35
26	9.829131	9.868093	9.961038	10.038962	10.131907	10.170869	34
27	9.829269	9.867978	9.961291	10.038709	10.132022	10.170731	33
28	9.829407	9.867862	9.961545	10.038455	10.132138	10.170593	32
29	9.829545	9.867747	9.961799	10.038201	10.132253	10.170455	31
30	9.829683	9.867631	9.962052	10.037948	10.132369	10.170317	30
		Sine		Tangent		Secant	Minutes

47 *Degrees.*

42 Degrees

Minutes	Sine		Tangent		Secant		
30	9.829683	9.867631	9.962052	10.03794	10.13236	10.170317	30
31	9.829821	9.867515	9.962306	10.037694	10.132485	10.170179	29
32	9.829959	9.867399	9.962560	10.037440	10.132601	10.170041	28
33	9.830097	9.867283	9.962813	10.037187	10.132717	10.169903	27
34	9.830234	9.867167	9.963067	10.036933	10.132833	10.169766	26
35	9.830372	9.867051	9.963320	10.036680	10.132949	10.169628	25
36	9.830509	9.866935	9.963574	10.036426	10.133065	10.169491	24
37	9.830646	9.866819	9.963827	10.036173	10.133181	10.169354	23
38	9.830784	9.866703	9.96408	10.035919	10.133297	10.169216	22
39	9.830921	9.866586	9.964335	10.035665	10.133414	10.169079	21
40	9.831058	9.866470	9.964588	10.035412	10.133530	10.168942	20
41	9.831195	9.866353	9.964842	10.035158	10.133647	10.168805	19
42	9.831332	9.866237	9.965095	10.034905	10.133763	10.168668	18
43	9.831469	9.866120	9.965349	10.034651	10.133880	10.168521	17
44	9.831606	9.866004	9.965602	10.034398	10.133996	10.168394	16
45	9.831742	9.865887	9.965855	10.034145	10.133113	10.168258	15
46	9.831879	9.865770	9.966109	10.033891	10.134230	10.168121	14
47	9.832015	9.865653	9.966362	10.033638	10.134347	10.167985	13
48	9.832152	9.865536	9.966616	10.033384	10.134464	10.167848	12
49	9.832288	9.865419	9.966869	10.033131	10.134581	10.167712	11
50	9.832425	9.865302	9.967122	10.032878	10.134698	10.167575	10
51	9.832561	9.865185	9.967376	10.032624	10.134815	10.167439	9
52	9.832697	9.865058	9.967630	10.032370	10.134932	10.167303	8
53	9.832833	9.864950	9.967883	10.032117	10.135050	10.167167	7
54	9.832969	9.864833	9.968136	10.031864	10.135167	10.167031	6
55	9.833105	9.864716	9.968389	10.031611	10.135284	10.166895	5
56	9.833241	9.864598	9.968643	10.031357	10.135402	10.166759	4
57	9.833377	9.864481	9.968896	10.031104	10.135519	10.166623	3
58	9.833512	9.864363	9.969150	10.030851	10.135637	10.166488	2
59	9.833648	9.864245	9.969403	10.030597	10.135755	10.166352	1
60	9.833783	9.864127	9.969656	10.030344	10.135873	10.166217	0
		Sine		Tangent		Secant	Minutes

47 Degrees

43 Degrees

Minutes	Sine		Tangent		Secant		
0	9.833783	9.864127	9.969656	10.030344	10.135873	10.166217	60
1	9.833919	9.864010	9.969909	10.030091	10.13599	10.16608	59
2	9.834054	9.863892	9.970162	10.029838	10.136108	10.165946	58
3	9.834189	9.863774	9.970416	10.029584	10.136226	10.165811	57
4	9.834325	9.863656	9.970669	10.029331	10.136344	10.165675	56
5	9.834460	9.863538	9.970922	10.029078	10.136462	10.165640	55
6	9.834595	9.863419	9.971175	10.028825	10.136581	10.165405	54
7	9.834730	9.863301	9.971429	10.028571	10.136699	10.165270	53
8	9.834865	9.863183	9.971682	10.028318	10.136817	10.165135	52
9	9.834999	9.863064	9.971935	10.028065	10.136936	10.165001	51
10	9.835134	9.862946	9.972188	10.027812	10.137054	10.164866	50
11	9.835269	9.862827	9.972441	10.027559	10.137173	10.164721	49
12	9.835403	9.862709	9.972695	10.027305	10.137291	10.164597	48
13	9.835538	9.862590	9.972948	10.027052	10.137410	10.164462	47
14	9.835672	9.862471	9.973201	10.026799	10.137529	10.164328	46
15	9.835807	9.862353	9.973454	10.026546	10.137647	10.164193	45
16	9.835941	9.862234	9.973707	10.026293	10.137766	10.164059	44
17	9.836075	9.862115	9.973960	10.026040	10.137885	10.163925	43
18	9.836209	9.861996	9.974213	10.025787	10.138004	10.163791	42
19	9.836343	9.861877	9.974466	10.025534	10.138123	0.163657	41
20	9.836477	9.861758	9.974719	10.025281	0.138242	10.163523	40
21	9.836611	9.861638	9.974973	10.025027	10.138362	10.163389	39
22	9.836745	9.861519	9.975226	10.024774	10.138481	10.163255	38
23	9.836878	9.861400	9.975479	10.024521	10.138600	10.163122	37
24	9.837012	9.861280	9.975732	10.024268	10.138720	10.162988	36
25	9.837146	9.861161	9.975985	10.024015	10.138839	10.162854	35
26	9.837279	9.861041	9.976238	10.023762	10.138959	10.162721	34
27	9.837413	9.860921	9.976491	10.023509	10.139079	10.162587	33
28	9.837546	9.860802	9.976744	10.023256	10.139198	10.162454	32
29	9.837679	9.860682	9.976997	10.023003	10.139318	10.162321	31
30	9.837812	9.860562	9.977250	10.022750	10.139438	10.162188	30
		Sine		Tangent		Secant	Minutes

46 Degrees

43 *Degrees.*

Minutes	Sine		Tangent		Secant		
30	9.837812	9.860562	9.977250	10.022750	10.139438	10.162188	30
31	9.837945	9.860442	9.977503	10.022497	10.139558	10.162055	29
32	9.838078	9.860322	9.977756	10.022244	10.139678	10.161922	28
33	9.838211	9.860202	9.978009	10.021991	10.139798	10.161789	27
34	9.838344	9.860082	9.978262	10.021738	10.139918	10.161656	26
35	9.838477	9.859962	9.978515	10.021485	10.140038	10.161523	25
36	9.838610	9.859842	9.978768	10.021232	10.140158	10.161390	24
37	9.838742	9.859721	9.979021	10.020979	10.140279	10.161258	23
38	9.838875	9.859601	9.979274	10.020720	10.140399	10.161125	22
39	9.839007	9.859480	9.979527	10.020473	10.140520	10.160993	21
40	9.839140	9.859360	9.979780	10.020220	10.140640	10.160860	20
41	9.839272	9.859239	9.980033	9.019967	10.140761	10.160728	19
42	9.839404	9.859119	9.980286	10.019714	10.140881	10.160596	18
43	9.839536	9.858998	9.980538	10.019462	10.141002	10.160464	17
44	9.839668	9.858877	9.980791	10.019209	10.141123	10.160332	16
45	9.839800	9.858756	9.981044	10.018956	10.141244	10.160200	15
46	9.839932	9.858635	9.981297	10.018703	10.141365	10.160068	14
47	9.840064	9.858514	9.981550	10.018450	10.141486	10.159936	13
48	9.840196	9.858393	9.981803	10.018197	10.141607	10.159804	12
49	9.840328	9.858272	9.982056	10.017944	10.141728	10.159672	11
50	9.840459	9.858150	9.982309	10.017691	10.141850	10.159541	10
51	9.840591	9.858029	9.982562	10.017438	10.141971	10.159409	9
52	9.840722	9.857908	9.982814	10.017186	10.142092	10.159278	8
53	9.840854	9.857786	9.983067	10.016933	10.142214	10.159146	7
54	9.840985	9.857665	9.983320	10.016680	10.142335	10.159015	6
55	9.841116	9.857543	9.983573	10.016427	10.142457	10.158884	5
56	9.841247	9.857421	9.983826	10.016174	10.142579	10.158753	4
57	9.841378	9.857300	9.984079	10.015921	10.142700	10.158622	3
58	9.841509	9.857178	9.984331	10.015669	10.142822	10.158491	2
59	9.841640	9.857056	9.984584	10.015416	10.142944	10.158360	1
60	9.841771	9.856934	9.984837	10.015163	10.143066	10.158229	0
		Sine		Tangent		Secant	Minutes

46 *Degrees.*

44 Degrees

Minutes	Sine		Tangent		Secant		
0	9.841771	9.856934	9.984837	10.015163	10.143066	10.158229	60
1	9.841902	9.856812	9.985090	19.014910	10.143188	10.158098	59
2	9.842033	9.856690	9.985343	10.014657	10.143310	10.157967	58
3	9.842163	9.856568	9.985596	10.014404	10.143432	10.157837	57
4	9.842294	9.856445	9.985848	10.014152	10.143555	10.157706	56
5	9.842424	9.856323	9.986101	10.013899	10.143677	10.157576	55
6	9.842555	9.856201	9.986354	10.013646	10.143799	10.157445	54
7	9.842685	9.856078	9.986607	10.013393	10.143922	10.157315	53
8	9.842815	9.855956	9.986860	10.013140	10.144044	10.157185	52
9	9.842946	9.855833	9.987112	10.012888	10.144167	10.157054	51
10	9.843076	9.855711	9.987365	10.012635	10.144289	10.156924	50
11	9.843206	9.855588	9.987618	10.012382	10.144412	10.156794	49
12	9.843336	9.855465	9.987871	10.012129	10.144535	10.156664	48
13	9.843465	9.855342	9.988123	10.011877	10.144658	10.156535	47
14	9.843595	9.855219	9.988376	10.011624	10.144781	10.156405	46
15	9.843725	9.855096	9.988629	10.011371	10.144904	10.156275	45
16	9.843855	9.854973	9.988882	10.011118	10.145027	10.156145	44
17	9.843984	9.854850	9.989134	10.010866	10.145150	10.156016	43
18	9.844114	9.854727	9.989387	10.010613	10.145273	10.155886	42
19	9.844243	9.854603	9.989640	10.010360	10.145397	10.155757	41
20	9,844372	9.854480	9.989893	10.010107	10.145520	10.155628	40
21	9.844502	9.854356	9.990145	10.009855	10.145644	10.155498	39
22	9.844631	9.854233	9.990398	10.009602	10.145767	10.155369	38
23	9.844760	9.854109	9.990651	10.009349	10.145891	10.155240	37
24	9.844889	9.853986	9.990903	10.009097	10.146014	10.155111	36
25	9.845018	9.853862	9.991156	10.008844	10.146138	10.154982	35
26	9.845147	9.853738	9.991409	10,008591	10.146262	10.154853	34
27	9.845276	9.853614	9,991652	10.008338	10.146386	10.154724	33
28	9.845404	9.853490	9.991914	10.008086	10.146510	10.154596	32
29	9.845533	9.853366	9.992167	10.007833	10.146634	10.154467	31
30	9.845662	9.853242	9.992420	10.007580	10.146758	10.154338	30
		Sine		Tangent		Secant	Minutes

45 Degrees.

44 *Degrees*

inutes	Sine		Tangent		Secant		
30	9.845662	9.853242	9.992420	10.007580	10.146758	10.154338	30
31	9.845790	9.853118	9.992672	10.007328	10.146882	10.154210	29
32	9.845919	9.852994	9.992925	10.007075	10.147006	10.154081	28
33	9.846047	9.852869	9.993178	10.006822	10.147131	10.153953	27
34	9.846175	9.852745	9.993430	10.006570	10.147255	10.153825	26
35	9.846304	9.852620	9.993683	10.006317	10.147380	10.153696	25
36	9.846432	9.852496	9.993936	10.006064	10.147504	10.153568	24
37	9.846560	9.852371	9.994189	10.005811	10.147629	10.153440	23
38	9.846688	9.852247	9.994441	10.005559	10.147753	10.153312	22
39	9.846816	9.852122	9.994694	10.005306	10.147878	10.153184	21
40	9.846944	9.851997	9.994947	10.005053	10.148003	10.153056	20
41	9.847071	9.851872	9.995199	10.004801	10.148128	10.152929	19
42	9.847199	9.851747	9.995452	10.004548	10.148253	10.152801	18
43	9.847327	9.851622	9.995705	10.004295	10.148378	10.152673	17
44	9.847454	9.851497	9.995957	10.004043	10.148503	10.152546	16
45	9.847582	9.851372	9.996210	10.003790	10.148628	10.152418	15
46	9.847709	9.851246	9.996463	10.003537	10.148754	10.152291	14
47	9.847836	9.851121	9.996715	10.003285	10.148879	10.152163	13
48	9.847964	9.850996	9.996968	10.003032	10.149004	10.152036	12
49	9.848091	9.850870	9.997221	10.002779	10.149130	10.151909	11
50	9.848218	9.850745	9.997473	10.002527	10.149255	10.151782	10
51	9.848345	9.850619	9.997726	10.002274	10.149381	10.151655	9
52	9.848472	9.850493	9.997979	10.002021	10.149507	10.151528	8
53	9.848599	9.850367	9.998231	10.001769	10.149633	10.151401	7
54	9.848726	9.850242	9.998484	10.001516	10.149758	10.151274	6
55	9.848852	9.850116	9.998737	10.001263	10.149884	10.151148	5
56	9.848979	9.849990	9.998989	10.001011	10.150010	10.151021	4
57	9.849106	9.849864	9.999242	10.000758	10.150136	10.150894	3
58	9.849232	9.849737	9.999495	10.000505	10.150263	10.150768	2
59	9.849359	9.849611	9.999747	10.000253	10.150389	10.150641	1
60	9.849485	9.849485	10.000000	10.000000	10.150515	10.150515	0
		Sine		Tangent		Secant	Minutes

45 *Degrees.*

A Table of *Angles*, which every Rumb (or Point of the *Compaſs*) maketh with the *Meridian.*

North.	*South*	*Point.*	*D.*	*M.*	*North.*	*South.*
		¼	02	49		
		½	05	37		
		¾	08	26		
N by E.	S by E	1	11	15	N by W	S by W
		1 ¼	14	04		
		1 ½	16	52		
		1 ¾	19	41		
NNE.	SSE	2	22	30	NNW	SSW
		2 ¼	25	19		
		2 ½	28	07		
		2 ¾	30	56		
NE by N	SE by S	3	33	45	NW by N	SW by S
		3 ¼	36	34		
		3 ½	39	22		
		3 ¾	42	11		
No. Eaſt	Sou. Eaſt	4	45	00	No. Weſt	Sou. Weſt
		4 ¼	47	49		
		4 ½	50	38		
		4 ¾	53	26		
NE by E	SE by E	5	56	15	NW by W	SW by W
		5 ¼	59	04		
		5 ½	61	53		
		5 ¾	64	41		
ENE	ESE	6	67	30	WNW	WSW
		6 ¼	70	19		
		6 ½	73	08		
		6 ¾	75	56		
E by N	E by S	7	78	45	W by N	W by S
		7 ¼	81	34		
		7 ½	84	23		
		7 ¾	87	11		
Eaſt	Eaſt	8	90	00	Weſt	Weſt

FINIS.